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School Science and Mathematics

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OPPORTUNITY AND OBLIGATION IN BOTANICAL TEACHING.

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Some years ago a high school graduate entering an eastern university offered botany as an admission unit. The application was accompanied by a certificate of high standing and a decorated book of herbarium specimens. When informed that still more was required to satisfy the committee the objection was met with mingled astonishment and protest. Why should the university refuse to accept botanical work of a high grade, accompanied by tangible evidence? "Very well, let us see if you know the subject," said the examiner. "What is the significance of the green color in vegetation?" To this question there was no reply.

The above incident, which came under the observation of the writer, was typical of the situation that frequently presented itself no more than ten or fifteen years ago. Descriptive botany overshadowed in some places, but in many others entirely excluded, vital features in the life of plants. This was naturally the result of the earlier status of botany in America. Systematic descriptions and the establishment of identity were necessarily the first steps in the development of the science, and the great works of Gray and Torrey, continued by their later disciples, for long years held the main interest in the botanical field. The vast region of the West was but little explored, and every collection was bringing in new and unknown species. Botanical literature was mainly systematic and hardly a thought was given to anything else. The enthusiasm of the masters was infectious and spread widely through schools, and cities, and towns. Circles of nature-loving folk met from time to time, botanical clubs and academies of science (broadening the field to

include zoology and geology), and various local organizations were formed and in some places are still active.

It has been the attempt of some to belittle this line of popular botanical interest and to charge the lack of general appreciation of botany to the ridiculous aspect it has sometimes displayed in the hands of superficial amateurs. That botany should be regarded as lacking in virility is at best but the superficial snap judgment of incompetent critics. There is no reason why any class of people who can gain an hour of recreation or leisurely enjoyment with the flowers of the field should not do so to their heart's content, or why their devotion to the purely aesthetic aspects of the subject should in any way prejudice its standing in the minds of thoughtful persons. But the attitude here referred to, viz., that of the public toward botany, is but the prejudice of ignorance and is no more excusable than the intolerance sometimes exhibited by the morphologist toward the systematist, or the systematist toward the morphologist, or by the workers in one field of science for those in another.

The devotion to systematic botany of some decades ago awakened an interest in the subject as an avocation in the minds of many professional men and others, some of whom gave it sufficient attention to accumulate valuable collections and to add to the list of plants known to science. Requiring, as it did, so little of expensive laboratory equipment, and with almost endless opportunity for education and enjoyment at hand, it is little wonder that so many found an abiding interest in the plant life of forest and field. Out of this period some emerged from the obscurity of rural communities to conspicuous positions in the history of American botany.

The incident cited in the beginning was significant only as showing the extreme to which the teaching of botany had gone in one direction. That the whole of botany should be in the names of the plants of course led to no immediate economic benefits and to no education of deeply cultural value. The reaction, however, came in the development in Europe and the introduction into this country of the morphological and physiological conceptions founded upon the work of Strasburger, Goebel, Sachs, Darwin, and others. This set forth the dynamic view of life. It revealed the plant as an organism. It awakened an interest in the study of structure, and function, and life history, and several other aspects, including ecology, pathology, and genetics, have since been added.

But now botanical teaching swung to the other extreme. Descriptive botany languished. Few teachers dared to present it at all in the face of the intolerance of the new school. Text-books appeared from every quarter, presenting courses of study especially for high schools, in which the main body of the text dealt with the microscopic form and structure and more or less complex life histories of strange and little known plants. The subject was usually introduced with a few pages of physiological definitions, and concluded with a brief appendix in which the descriptions of a few common plants were supposed to be given. This vestige, like its vermiform namesake, was to be promptly excised if it showed the least sign of causing irritation. It seldom had the chance to become congested for it was eliminated in advance.

Under this brave system high school pupils of tender years were faced at the start with the compound microscope and preparations of minute microorganisms and complex transverse sections unrelated to anything before heard of in the pupil's experience, and the connection, if there was any, with life interests of any sort was either overlooked or purposely omitted. The subjects frequently carried the incubus of long and unfamiliar Latin names. Lengthy and laborious laboratory exercises with the requirement of drawings which in the end showed little comprehension of the subject resulted in the removal of botany from the condition of familiar interest to a status conceived as foreign and remote from ordinary human affairs. It might have its application but nobody seemed to know just how, or when, or where. The claim of the disciplinary value of the laboratory method was worked overtime to justify it. One may almost search in vain in the earlier texts for an interpretation of botanical science in relation to everyday human interests.

From the standpoint of the teacher of this period the outlook was not more encouraging. Quickened by the research impetus of German universities, our American professors during the last two or three decades have been busy with investigation and publication, and productive authorship was and is yet almost the only claim to professional recognition. Students seeking their doctorates in American universities were assigned to some narrow research problem, the satisfactory consummation of which was rewarded by the degree. Thus equipped, the newly fledged doctor went forth to teach in high school or college, often with little knowledge of botany beyond the restricted field of his

thesis. In most cases he knew little about the native flora and cared less. His pupils were not encouraged to seek the names of plants. The teacher was seldom at home in the field and avoided field work with his pupils, who might ask too many questions about the names of things. If he didn't know the name he was ready to reply, "We don't consider the names of plants important; the main thing is their structure and life." This of course is true, but it was not convincing, and usually failed to satisfy or inspire the student.

In the classrooms and laboratories also a radical change took place. No longer the simple equipment of the herbarium, but the costly outfit of microscopes, microtomes, glassware, and reagents that complicated the approach to the subject, increasing the psychological resistance in the mind of the student and deterring school boards and administrators from incurring the expense incident to the equipment of botanical courses, the more especially that their application was allowed to remain more or less obscure.

Taking all these things into consideration, viz., the inadequacy of the textbooks, the incompetence of the teachers, and the expense of the work, it is not strange that botany as a subject for secondary schools has had difficulty in gaining recognition and maintaining its place. Where it has prospered under this system it has perhaps been due more to the personality of the teacher than to the attractiveness of the subject.

So the pendulum of botanical teaching has swung from what one writer of the later school was pleased to characterize as "mere petal-pulling calisthenics" to the other extreme of pedagogical futility, the exaggerated emphasis upon remote and technical details. Within recent years, however, the revival of interest in evolution and the genetic relationships of plants, through the work of De Vries and the mutationists, has furnished a new channel for the botanical current which promises to bring it again within the range of popular appreciation. As soon as the public becomes conscious of the direct connection between botanical science and human welfare, as it bids fair to become by this means, there will be no further debate as to the justification of botany in the schools.

The present tendency in education is all toward the so-called practical considerations. The economic urge is felt everywhere. We must write the dollar mark before anything that we hope to have generally accepted. The few who are interested without

such influence are effete and effeminate; they are sometimes tolerated but rarely followed. Even the National Education Association is seeking to reduce the material and the time in primary and secondary training merely for the avowed purpose of forcing students earlier through the professional schools that they may hasten their emergence into professions already overcrowded with poorly trained practitioners. It is an undesirable condition, but the virus is everywhere in the blood, and we might as well face it and make the most of the situation. "The impatience of fundamental training," writes the Dean of an eastern graduate school, "is the fundamental weakness in American education and by consequence in American life." While I am far from advocating the study of botany or any other subject purely for its economic advantages, we shall, I believe, be justified in appealing to an economic interest to preserve what is of value from the standpoint of the cultural and the aesthetic as well as the economic.

There are at present few phases of material human interest which have not some connection with plant life; food, fuel, houses, furniture, clothing, books, papers, medicines, and many other articles are furnished in whole or in part by the plant world. Not only, however, in the production of these articles, but also in the loss of them, are we concerned with plants, for the agencies of decay are vegetable organisms, and many of the most widespread and destructive diseases of crops are due to parasitic plants.

It is hardly realized by most people that the heart of scientific agriculture lies in the field of botany, the knowledge of plant physiology as applied to crop production, the knowledge of the principles of heredity as applied to the improvement of crops, and the knowledge of plant diseases as applied to their protection. One-half of forestry is applied botany; silviculture deals with the production and maintenance of the forest. On this production the business of utilization or lumbering depends. Silviculture calls for a knowledge of plants as applied to trees in the forest. Pharmacy is another subject which in its materials and methods is dependent upon a familiarity with medicinal plants, their structure and composition, and a long list of vegetable products which make up a large part of the materia medica, and those which are important both as necessities and luxuries, from tooth powders to spices and oils. From commercial in-

terests of this sort, it is not far to other industrial relations of plants, as represented by textiles, rubber, etc.

It is, however, in the field of agriculture that the economic importance of botany is most conspicuous. The cultural conditions of crops from the selection of seed to the harvest are inseparable from the principles of plant physiology. The first step in intelligent planting is intelligent selection of seed, and intelligent selection involves several considerations, viz., the size and composition of seeds and their viability or germinating capacity, whether prompt, vigorous, and abundant, or slow, weak, and numerically low. Such determinations are not difficult to make, but the percentage of error is largely reduced when they are conducted by trained hands. That the planting of well-selected seed means improved races of plants and increased yield is one of the oldest established facts in agriculture, but in practice too little attention is given to it even now. How much the yield of grains and other war foods may be increased by proper attention to seed selection is a matter distinctly worthy of attention at the present time.

In the growth of plants from the seed, the relations which their roots establish with the soil particles, the absorption of moisture and its transport through the plant, the quantitative relations of different plants to air and light, the things which effect retardation or acceleration of maturity, the influences which modify or control the fruitage, immunity or susceptibility to disease, matters of pollination and fertilization, all are purely botanical. The line of demarcation between the botanist and the agriculturist is that the former is more concerned with the principles that control plant growth, the latter with their specific application. Why should not the specific application be made in the botanical classroom instead of leaving all the significant phases of the subject to be taken up by the course in agriculture? Already a large part of the botanical field, bacteriology, agronomy, and horticulture, is taken up by men who are dealing with botanical matters but who seldom or never consider themselves botanists. Already the tendency is evident to subordinate departments of pure science to technical schools and to remove them from the field of liberal education, and if this trend is to be checked it will be by making the courses of sufficient breadth and economic significance to interest a large body of people.

But botanical science is not concerned alone with the plant-

ing and cultivation of plants but with their improvement as well. In this connection I refer to the plant breeders, whose work with the plants of the field, garden, and orchard has laid the world under deep and permanent obligation by giving us the highly developed varities which beautify, enrich, and sustain life. The highly productive races of cereals, the splendid varieties of potatoes and root crops, the delicious fruits are the products of crossing, selection, and propagation. Few plants there are of the farm or garden which in their desirable features have not been accentuated by the botanist in the particular role of the plant breeder. Back of all the concrete and tangible contributions of grains, vegetables, and fruits is the earnest search for the underlying laws which determine heredity, the knowledge of which will enable us to predict with certainty and to execute with precision in dealing with living races and their relations to human interest. Probably at no time in previous history has the industry in this line of investigation equaled that of the present day.

In the work of the plant breeders then, lie inconceivable possibilities for the sustenance of mankind. The first and greatest problem of the human race in all time has been that of food, and the increased productiveness of his fields has been one of man's greatest triumphs over the conditions of his environment. It is this triumph which has made possible the present long-sustained conflict, and the ability further to sustain the struggle will depend largely upon the products of the soil and back of these the intellectual resources as represented by scientific achievement in the realm of the natural no less than in that of the physical sciences.

But in still another phase is the knowledge of botanical science essential. It avails little to plant, and water, and cultivate, and select, if we are to lose the crop by pests and parasites. It is stated on good authority that 133,000,000 bushels of cereals are lost annually through the ravages of preventable diseases. The average farmer probably does not realize that his crop is diseased before the loss has amounted to fifteen to twenty per cent, and it may go to as much as thirty per cent before he will proceed to remedial measures. It is not difficult to see what the loss of so much grain means to the country at large any time, but in the present emergency it is far more than dollars and cents. The public as a rule has no conception of the losses due to plant diseases, and consequently quarantine measures

and proper safeguards are not readily secured. In the face of present necessity it would seem to be as criminal to allow food crops to be destroyed wholesale as to expose communities to contagious diseases. Crop-destroying diseases are as contagious as any that affect the human body, but the public sense of the importance of crop sanitation is almost as deficient today as it was with reference to personal sanitation one hundred years ago. Here, then, is both the educational opportunity and the obligation at the door of botany.

Cereals, however, are not the only crops depleted by fungi. Blights often ruin potato crops. They attack fruit trees and whole orchards must sometimes be removed. Indeed there is hardly a form of crop plant, or for that matter of plants in nature, which is not attacked by some vegetable parasite. The study of these parasites, the conditions of their life and development, are being studied by botanists and remedies are being discovered. It is now required that barberry bushes be eradicated, inasmuch as they furnished a necessary link in the life habits of certain grain rusts. It is shown that much grain can be saved simply by the elimination of the barberry, and quarantine measures are now generally in force with reference to this plant.

Impressed as we are with the importance of food in winning the war, and urged as we are by the Food Administrator to save at every turn, we are still face to face with the enormous loss due to plant diseases attacking the crops most important from the war standpoint. The recognition of this fact was expressed in no uncertain terms last winter at the meetings of the American Association for the Advancement of Science, and botanical societies have taken steps to see that their fullest powers are enlisted in the present emergency.

While forest products, lumber, etc., are not in danger of immediate shortage to a degree that would endanger the country, nevertheless some very destructive diseases, recently imported, are now at work in the eastern states. One of these has already resulted in the destruction of all chestnut trees over large areas on the Atlantic coast, and the other gaining headway in the white pine woods of Wisconsin and Minnesota, threatens to take disastrous toll of our Rocky Mountain and Pacific Coast forests. Add to this outlook the less extensive but still fatal ravages of some of our native tree diseases, and the fact that wood-rotting fungi are responsible for from seventy-five to ninety-five per cent of the depreciation and loss of structural timbers, and the

importance of this one group of small plants, the fungi, becomes distressingly apparent.

Instances might be multiplied, and other bearings of botany upon human interest and prosperity might be expanded upon indefinitely, but the above cases will suffice to show how much a knowledge of botany may be of service in popular education. All service which increases and conserves the wealth of the country is at all times a public benefit, and especially if the same service enhances the possibility of equitable distribution of that wealth. In the matter of natural resources the public opportunity is particularly a precious heritage, and it is hard to conceive of a line of educational effort fraught with greater possibilities than is that which deals through the life of plants with the products of the soil.

While material well-being is essential to the enjoyment of large opportunity, it must never be forgotten that the greater benefits are those of the cultural, the spiritual, the aesthetic, the mental depth and breadth of men. It is in this field that the truest national interest lies, even more than in the other, and if at this time it seems to have suffered neglect it is only because in the space allotted to this paper it is sought to set forth the particular urgency of a material concept in relation to botanical education. The knowledge, however, of life in its relation to human existence, in fact, the actual dependence of human life upon plants, is a fact as important in liberal education as any that can be contributed by other subjects in the curriculum. The time would seem to be past when one can lay claim even to ordinary education who is ignorant of facts of such far-reaching and fundamental importance as those which are included in the nature and activities of the plant world.

LIMITATIONS OF THE BALANCE.

B. Blount reports the results of weighings on six balances of the best make (Oertling, Bunge, and Sartorious) made by three people at two different places, over a period of four months, all necessary precautions being taken. Variations of from .4 to 1.6 mg. were observed and could not be correlated with any variation of external conditions. The effects could not be accounted for by any difference in the temperature between the two arms of the beam, nor by the existence of unequal stresses in the arms. Two of the balances had their knife edges set in sealing wax, two had them held by set screws, and in the case of the other two they were apparently pressed in. In all three methods of construction, fortuitous movement of the knife-edge is easily conceivable, thus bringing about an alteration in the effective length of the two arms of the balance, and it is to this explanation that the author inclines.

RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins.

University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

SOME PROBLEMS FOR FUTURE SOLUTION.

By B. S. Hopkins,

Division of Inorganic Chemistry, University of Illinois, Urbana.

We recognize the existence of over eighty definite chemical elements among those forms of matter which we are enabled to examine. Some of these are very rare and are known only as curiosities, while others are so common and abundant that they fail to interest the beginner in the study of nature. In his interesting work on geochemistry, Dr. F. W. Clarke gives tables showing the relative abundance of these common elements, and calls attention to the fact that the eighteen most common elements comprise 99.51 per cent of the earth, water, and atmosphere. One would expect all the elements in this brief list to be so common and so thoroughly mastered by the scientists of our day that there would be no problems involved to interest those engaged in research. It is natural to expect that all the unanswered questions in regard to properties and uses of the elements must certainly deal with those sixty-odd individuals whose sum total comprises less than half of one per cent of the planet upon which we live. But let us examine these eighteen elements and see how really familiar they are to us. The second most abundant element is silicon, which comprises over one-fourth of the matter in the world which is known to us. Its compounds have been known and used by mankind since the very earliest times. In such forms as quartz, agate, amethyst, opal, garnet, and beryl it is highly prized and widely admired; in manufactured forms like glass, china, porcelain, and carborundum it contributes largely to the comfort and progress of man. But the element itself has been until recently almost an unknown substance. As late as the year 1900 silicon sold for museum purposes only at a price as high as $4 per gram. Through the development of electrical industries, especially at Niagara Falls, silicon has become available in large quantities and at a very low cost. It was true recently that the producers were

glad to obtain ten cents a pound for silicon, but it found no sale because no one knew how to use it. It is now being used to a limited extent for removing dissolved gasses from steel and for making certain acid-resisting alloys. But the element is capable of very greatly increased usefulness and as we become better acquainted with this material, which is now available in unlimited amounts and at low cost, we shall undoubtedly find some most interesting and useful properties.

The element standing fifth in the list of common elements is calcium, which constitutes over three per cent of the earth and its envelopes. It is an element which is just emerging from the curio cabinet and finding a place among the useful elements, although man has long used many of its compounds, such as the familiar limestone, marble, alabaster, chalk, gypsum, plaster of Paris, lime, cement, and a host of other everyday substances. The element itself is now produced satisfactorily but only in small amounts and at a cost of something like $3 per pound. This price is certain to be lowered materially as new uses are found for the element and the increased demand stimulates investigation upon improved methods of production. We have almost no use whatever for the metal at the present time, and its influence upon other metals in the formation of alloys is almost entirely unknown. Yet its properties suggest some very interesting possibilities, and this element ought to become a very useful one as soon as we are able to learn how to use it.

Potassium stands seventh in the list of the most common elements. It is neither a curiosity nor is it difficult to obtain, but the outbreak of the war brought American chemists and manufacturers suddenly to a realization of the fact that we have been depending upon Germany for our supply of potash material. It is safe to state that there are as many American chemists today working upon some phase of the potash problem as upon any other one problem of chemical research. The results of this intense effort are showing themselves by the rapid strides made in meeting the demand for potash. A recent statement given out by the Nebraska Conservation and Welfare Commission credits the state of Nebraska with a daily production of more than 400 tons, valued at $60,000, whereas three years ago Nebraska produced no potash at all. In September, 1917, at a meeting of the Portland Cement Association in Chicago, the General Manager of a well-known cement firm made the statement that the profits from the sale of potash from the first year's work in

potash recovery at their plant had more than covered the cost of the recovery plant and that they were making more money from potash than from cement. Later statements from other cement firms are along the same line and indicate that under present conditions potash is the main product and cement a by-product. Encouraging reports of progress are also made from the efforts to recover potash from the Searles Lake deposits in California, from the alunite of Utah, from the kelp of the Pacific Coast, from the feldspathic rocks of various localities, from the cotton and tobacco stems of the South, from the corncobs of the corn belt, and from a variety of other sources. These problems are rapidly being solved so far as present conditions are concerned, but there will be other and more difficult problems after the war is over and these new industries are brought into keen competition which is certain to come. The solution of these problems is essential in order that America may never again be dependent upon the whim of other nations for its stock of so important a material as potash.

Coming next to potassium in abundance is magnesium, a metal which has been known for over a century. Its compounds are abundant and cheap, its metallurgy presents no particular difficulties, its properties are valuable, yet the cost of the metal and its alloys is entirely out of proportion to the cost of the raw material. Precipitated magnesium carbonate, guaranteed ninety-eight per cent pure, may be bought in carload lots for eleven cents per pound and raw magnesite is priced at $25 per ton. With such prices for the compounds there is no reason why we must pay $3.50 per pound for the metal in the ingot form and why we cannot buy magnesium ribbon at any price. The alloys of magnesium possess properties which would bring them into very general use, but their high cost limits their applications to a few special purposes. We are greatly in need of better metallurgical methods for magnesium in order that it may take its place among the widely used metals.

The tenth element in the order of frequency is titanium, an element which has been badly neglected by chemists. In the free state it is almost unknown, although Berzelius prepared the metal nearly a century ago. It sells at the present time for $5.50 per ounce, while its most common ore, nearly pure TiO_2, may be had in any quantity for less than one cent per ounce. This difference in cost is not due to any scarcity of the raw material, since titanium is found in more than sixty distinct

species of minerals, some of which are very abundant. Titanium is present in small amounts also in most sands, clays, and granite rock, while it is frequently found in mineral waters, plants, and the bones of animals. The high cost of the elements is due to the fact that no progress in its metallurgy has been made during the past century. There is no doubt but that the metal could be produced at much lower cost than at present, if sufficient stimulus were exerted. There is no demand for the substance, because no one knows how to use it. Consequently the element is neglected and undeveloped through lack of interest and intensive study. Even the use of titanium alloys and compounds has developed slowly, due chiefly to the fact that most of the applications require pure materials, and these are not now available at reasonable prices. The principal use of titanium material at present is in the form of alloys, such as ferro-titanium or ferro-copper, which are used in considerable quantities for removing dissolved gases, especially oxygen, from molten metals like steel or bronze. Some titanium compounds are used in bleaching, mordanting and dyeing of textiles and leather, and in smaller amounts in the ceramic, dental, paint, and abrasive industries. There is every reason to believe that these applications would be greatly extended and many new ones suggested if we knew more about these compounds and their preparation.

Barium is one of the least abundant of the eighteen most common elements, but its compounds are available in unlimited amounts and in very pure form. The production in the United States for 1916 is 200,000 tons, approximately four times the amount mined two years previously. This material, ninety-nine per cent pure, is to be had on the Atlantic coast for $18 per ton. The cheapness and high specific gravity of barytes makes it perfectly natural that this material should be used as an adulterant in the cheapest paints. In spite of the commonness and cheapness of its compounds, barium itself has probably never been prepared in a purer form than ninety-eight per cent. The unusual stability of barium compound as well as the properties of the best barium which has ever been produced, lead us to expect that the element would be extremely useful if it could be obtained at a reasonable cost. The nearest approach, apparently, to a use for metallic barium is in the form of a lead alloy which is being used to some extent in the automobile industry. But this may hardly be considered a beginning to the applications to

which this metal will be put as soon as we learn how to prepare it and its alloys.

Thus we see that out of Dr. Clarke's list of the eighteen most common elements, fully one-third offer attractive fields for the investigations of the chemist and metallurgist. In many cases the need for more complete information is very urgent, and in all cases the prospect of adding materially to the progress of human advancement is inviting. It is certain that information concerning some of these elements will be one of the results of the present demand for efficiency and the conservation of our natural resources. It is safe to predict that before many years some of these curiosities will become familiar articles of commerce, serving the comfort, preserving the health, or conserving the effort of the human race. If this statement seems visionary it is necessary only to consider the recent history of aluminum. It is the third most abundant element that we know, forming over seven per cent of the earth, and its compounds are found everywhere, and have been used since time immemorial for a great variety of purposes. Aluminum material is said to be "as common as dirt," yet up until comparatively recent times the element itself was entirely unknown. It is recorded on good authority that in 1855 aluminum was sold at the rate of $275 per pound. For a good many years following, the element was a rare curiosity with a price which classed it among the precious metals. In our day aluminum has fallen below twenty cents per pound, and this new metal has taken its place as one of the most useful and valuable products of scientific intelligence and skill. What American brains and determination succeeded in doing for aluminum may also be accomplished in the case of others of the eighteen so-called "common" elements.

These problems are waiting for solution. When these mysteries have been untangled and new forms of material take their places in the commerce of our day, people will wonder how their unfortunate predecessors could have gotten along without these conveniences, just as we today wonder how battles could be fought without airplanes, how artificial lighting could have been possible without the tungsten filament, or how a fire could have been kindled without the friction match.

CHANGES, PHYSICAL AND CHEMICAL.

By Creig S. Hoyt,
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When a material system is acted upon by some form of energy, we observe a change. That change may be slight and, on the other hand, it may be deep-seated. We have, for convenience in teaching, arbitrarily classified these changes, which we observe in a material system, as physical and chemical. Those changes in matter which are so slight that the energy change is by comparison very great are treated under the subject of physics. Similarly, those changes in matter which are so deep-seated that the energy change is by comparison unimportant are treated under the subject of chemistry.

Such a classification can be considered in no sense categorical. The criteria on which we base our classification are such that a single change might be classified as either chemical or physical, depending on the viewpoint of the observer. At best, the classification is simply an endeavor to roughly divide phenomena, and cannot be considered as fundamental to the science. Its justification lies not in the nature of the science, but in the necessity of the teacher.

From this arbitrary classification, several errors have arisen. Some of these are scientific, some pedagogical. They are due, first, to misconception of the criteria on which the classification is based; and, second, to the habit of considering the classes as categorical and mutually exclusive.

In many texts, the criterion by which one judges whether a change be physical or chemical is evidently the reversibility of the reaction, or, in other words, whether the material be permanently or temporarily altered by the energy change which it has undergone.

"When we notice the things about us, we see that they undergo changes: a piece of wood bends under a weight or warps when wet; a rod lengthens when heated; a piece of iron placed near a magnet attracts another piece of iron. If we remove the weight from the stick, it straightens; the iron removed from the magnet loses its power of attraction. In such changes, although the object may be considerably altered, we still recognize the pieces of the stick as wood, as we do the fragments of a broken tumbler as glass; that is, the material has not lost or changed those peculiar properties or characteristics by which we identify

it. Such changes are called physical changes; they result usually in a change of such properties as size, shape or color."[1]

It is evident that such a standard would bar from chemical changes some reactions which are easily reversible. It is possible to bring about a chemical change in matter by an application of a form of energy, which can be reversed by the removal of the source of energy. For example, on heating the white solid, ammonium chloride, two gases, ammonia and hydrogen chloride, are formed, but a return to the original temperature causes a reversal of the dissociation with the formation of ammonium chloride. Reversibility affords no criterion of the nature of a change. The polymerization of water on freezing would be physical if viewed from the ease of its reversibility and chemical if viewed from its radical change in properties.

Another standard by which it is judged whether a change be physical or chemical is the loss or gain of distinctive properties. Such a standard might be scientifically correct, provided one chose the right properties. The usual test, however, is that the final substance be recognized as the original material after the application of the energy change. Since distinctive properties may easily be lost or gained without a change in the composition of a substance, the observer may easily be led astray. To conclude that the beginning student will choose the most fundamental properties of a substance rather than the most obvious properties is a mistake pedagogically.

Again, it is a mistake to assume that all changes are either physical or chemical. The phenomenal growth of the relatively new science of physical chemistry is evidence for that statement. The classification of reactions into physical and chemical can not be as rigid as one would be led to believe from the teaching of elementary chemistry. A large portion of chemistry is a refined study in physics. There are many changes taking place as important in their energy aspect as in their material side.

Physical changes are sometimes defined as changes in condition, while chemical changes are changes in composition. We should resort to analysis to establish differences in composition. Yet an analysis would fail to show any change in composition when sodium chloride goes into solution, although two new materials are formed in that process, the sodium and chloride ions. These have properties which differ both from sodium chloride and from the sodium and chlorine of which it is composed.

[1]*First Principles of Chemistry*, Brownlee, Fuller, Hancock, Sohon, Whitsit.

Molecular association in liquids is another phenomenon which could not be classed as chemical by an analysis, since strictly no change in composition has occurred. Our evidence of it is obtained through surface tension, a physical phenomenon.

An analysis of the content of physics and of chemistry reveals that the systems studied are in most cases identical. The distinction is principally that in physics we are primarily interested in the energy change, as such, while in chemistry we are interested in the change in the material system produced by energy with less attention focused on the energy change itself. The physicist, as a rule, avoids a study of an energy change in a material system where the material change is great, since it tends to make the formulation more difficult. The treatment accorded the Voltaic cell and the new science of radio activity in the physics course shows need for the physicist to abandon his strict classification, and consider material as well as energy change. The older chemistry ignored the energy change and concerned itself altogether with the material change. To such a chemistry, the strict classification might be applicable. The newer chemistry is concerned not so much with tabulating properties and unallied reactions, but with formulating chemical changes according to the energy cause or accompaniment. The change in mass has ceased to be our prime interest. The student of elementary chemistry should be introduced to the modern chemistry and early learn the importance of energy in chemical reactions. Otherwise, chemistry becomes cookery. The present introduction to the science is, then, altogether inappropriate to the subject matter. It has failed to advance as has the rest of chemistry.

Is there need for such a classification? It is not necessary to the science. It is not a true generalization. It confuses rather than aids the student. And, finally, we have no real criterion by which to judge to which category a particular change should be assigned.

ONE OF TYNDALL'S "LIGHT" EXPERIMENTS.

One part gum mastic is dissolved in eighty-seven parts grain alcohol, and a few drops of this solution are added to a vessel of water, while the vessel is vigorously stirred. The gum mastic, being insoluble in water, forms a very fine precipitate which remains in suspension in the water. If the vessel is now viewed against a black background, with the light coming from the side or above, the water can be seen to give a very fair sky blue color, while transmitted light (shown best by placing the vessel between an arc light and a white screen) is a rich golden yellow, like sunlight.

MAP SCALES.

By R. M. Mathews,
Duluth, Minn.

Military operations are planned and executed with constant use of well-made maps. General Kuropatkin has attributed the failure of some of the operations in the Russo-Japanese War partly to the inability of so many of the officers to read maps; as a consequence the movements of the troops were conflicting and dilatory. Army men say that the best way to learn to read a map is to make one. In the Army schools there are regular courses in which an officer learns to make maps from the simple road sketch, from data determined by pacing or horse trot, to the elaborate topographical maps based on careful surveying operations.

Map making is based mathematically on ratio and proportion, and furnishes some interesting material for concrete applications of the theorems on similar figures in geometry, which is a part of the subject in need of new practical problems. This paper contains some material in the way of theory and problems which it is easy to introduce into the course on geometry with enlivening results.

Explanations.

To get clear ideas about a particular part of the earth's surface we make maps of the land. For each place on the ground there is a point on the map, but the distance between two points on the map is much less than the distance between their stations on the ground.

The scale of a map is the relation of the distance between two points on the map to the distance between their corresponding stations on the ground.

Distance on the ground means *horizontal* distance. Thus the distance between two points on a steep slope is the length of the horizontal line intercepted between the two plumb lines at the stations.

The scale of a map can be specified in three ways:

1. *Verbally*, as 3 inches to the mile.
2. *Numerically*, by a representative fraction (R. F.).

$$\text{R. F.} = \frac{\text{Map distance}}{\text{Ground distance}}$$

When both distances are numbers of the same denomination, the fraction is usually reduced to an equal fraction with unit numerator, as 3 inches to the mile gives R. F. = 1/21120.

3. *Graphically*, the scale being shown by a line on the map or by a length marked on a ruler.

The first method of giving the scale of a map is convenient in discussions and descriptions; the second is the basis for making calculations; while the third must be used to make maps or to read them. Indeed, graphical scales are of two kinds, namely, working scales, for plotting, and reading scales. A single scale would do if a map were read in terms of the units used for plotting it, but often the distances have been obtained in terms of strides of various lengths, while the map will be used in terms of yards or of miles.

It is needful to be able to express a scale given by one method in each of the other two ways. The simple properties of proportions in algebra and geometry enable us to do so.

All calculation centers around the representative fraction. By definition the representative fraction is an abstract number when the distances on the paper and on the ground have been measured in terms of the same unit. When the distances have not been so measured, then: (1) the measurements must be reduced to the same unit; or (2) the unit must appear as part of the number. To introduce the name of the unit as a factor and to treat it as such, expedites the solution of many problems. The following examples illustrate this statement among other things.

(1) What is the R. F. when the scale is three inches to the mile?

$$\text{R. F.} = \frac{3 \text{ inches}}{1 \text{ mile}} = \frac{3 \text{ inches}}{5280 \text{ feet}} = \frac{3 \text{ inches}}{5280 \times 12 \text{ inches}} = \frac{1}{21120}$$

(2) A foreign map is made on a scale of 2 cm. to the km.; how many inches to the mile is that?

$$\text{R. F.} = \frac{2 \text{ cm.}}{1 \text{ km.}} = \frac{2 \text{ cm.}}{1 \times 1000 \times 100 \text{ cm.}} = \frac{1}{50000}$$

$$\frac{1}{50000} = \frac{1 \text{ mile}}{50000 \text{ miles}} = \frac{1 \times 63360 \text{ inches}}{50000 \text{ miles}} = \frac{1.267 \text{ inches}}{1 \text{ mile}}$$

(3) A man's stride is 64 inches. Construct a graphical scale about 6 inches long which will map his strides in the proportion of 3 inches to the mile.

$$\text{R. F.} = \frac{1}{21120} = \frac{1 \text{ stride}}{21120 \text{ strides}} = \frac{1 \times 64 \text{ inches}}{21120 \text{ strides}}$$

$$= \frac{5.33 \text{ inches}}{1760 \text{ strides}} = \frac{3.03 \text{ inches}}{1000 \text{ strides}}$$

Lay off a line 6.06 inches long and mark it 2,000 strides. Bi-

sect it and mark the center point 1,000 strides. Divide one part into 10 equal parts (by the regular geometric method) to obtain the length for 100 strides and divide the last of these into five equal parts to show 20 strides.

(4) Correction of erroneous scales. A map was plotted to a scale of 3 inches to the mile from data gathered on the assumption that the observer's pace was 32 inches. After the map was finished it was found that his pace was 30 inches. What is the actual scale of the map? and what length should be taken for 1,100 yards to make a reading scale for it?

The map was actually plotted in the relation 1/21120. that is,

$$\text{R. F.} = \frac{\text{1 pace on map}}{\text{21120 paces on ground}}$$

Had the pace on the map been equal to the pace on the ground the map would have been correct. But the first was 32 inches and the second 30 inches, so

$$\text{R. F.} = \frac{1\times 32 \text{ inches}}{21120\times 30 \text{ inches}} = \frac{1}{19800}$$

$$\text{Again,} \quad \frac{x \text{ inches}}{1100 \text{ yards}} = \frac{1 \text{ yard}}{19800 \text{ yards}}$$

$$\frac{x \text{ inches}}{1100\times 36 \text{ inches}} = \frac{1 \text{ yard}}{19800 \text{ yards}}$$

whence $x = 2$ inches for 1,100 yards.

(5) From a map made 6 inches to the mile the distance AB reads 6,004 yards, whereas AB is known to be 6,000 yards. Examination shows that the 300-foot tape used was too short. How much was it too short, and what is the true scale of the map?

The defective tape is contained in the true distance just as many times as a true tape is contained in the false distance. So, if x be the defective length,

$$\frac{6000}{x} = \frac{6004}{300} \qquad \text{whence } x = 299.8 \text{ feet.}$$

$$\text{Now,} \quad \text{R. F.} = \frac{1}{10560} = \frac{\text{1 tape length for map}}{\text{10560 tape lengths on ground}} =$$

$$\frac{1\times 299.8 \text{ feet}}{10560\times 300 \text{ feet}} = \frac{1}{10567}, \qquad \text{true R. F.}$$

The "scale" of a map refers always to its linear dimensions, while the "size" of a map means its area. To double or triple the scale doubles or triples the length of each line. To double or triple the size doubles or triples the area, and therefore multi-

plies the linear dimensions by $\sqrt{2}$ (or $\sqrt{3}$), for the areas of geometric figures are proportional to the squares of their dimensions.

(6) A map made on the scale of 1/21120 is reduced to one-fifth its size in photographic reproduction. What is the new scale of the map?

In the new map, what was 1 inch in the old has become $1/\sqrt{5}$ or .447 inches, and yet corresponds to the same distance on the ground.

$$\text{R. F.} = \frac{1/\sqrt{5}}{21120} = \frac{1}{21120\sqrt{5}} = \frac{1}{47225.5}.$$

A stride is two paces. The advantage of counting strides rather than paces is that the count is reduced one-half. The average length of a person's stride is determined by finding the average number of strides he takes in covering a standard distance at a firm, even walking gait. Have the standard course marked out by measuring a 1,000 feet or so on the street or road by the school.

Problems on Map Scales.

1. Determine the average length of your stride. Pace the "standard distance" each way three times, counting the number of strides for each course. Take the average of these six numbers. Divide this into the known length of the course and obtain the average length of stride correct to the nearest inch.

2. Compute your number of strides for 100 and 1,000 yards and for a mile. Compute your distance in yards for 100 strides. Take the nearest integer as the correct result in each case.

3. Compute the R. F. for maps of 1, 3, 5, 2 3/4, and 6 inches to the mile. Compute the R. F. for maps of 1, 2, 5, and 3 1/2 centimeters to the kilometer.

4. Determine the R. F. for each of the maps indicated by the instructor.

5. Construct your working scale of strides to plot a map at 3 inches to the mile. The scale is to be carefully made on a piece of cardboard about 6 inches long.

6. Construct a reading scale, to use with a map plotted with your stride scale, to give the distances on the map in terms of yards on the ground. Mark this scale on the edge of the cardboard opposite the stride scale.

7. Construct a reading scale of yards to use on a foreign map where the scale is 2 centimeters to 1 kilometer.

8. Suppose you have a map of a locality but that the scale is not given. Explain how to determine the scale of the map.

9. In hostile country you secure a map of the locality without a scale. 20 inches on the map is the distance between the 20th and 21st degrees of latitude. Determine the R. F. of the map and construct a graphical scale of yards.

10. Find the true scale of a map that was made to be 4 inches to the mile, the pace being supposed to be 35 inches when it was really 36 inches. Is the scale of the map larger or smaller than was required?

11. An officer was ordered to make a sketch on the scale of 3 inches to the mile. This he did, supposing that his pace was 29 inches. Afterward he found that a distance of 4,000 yards scaled from the sketch measured 4,125 yards on the ground. Find his true length of pace and then determine the actual R. F. of the map.

12. A map R. F. = 1/9000 is enlarged to three times its size. What is the new R. F.? How are the linear dimensions changed? If this same map be reduced one-fifth its size, how will the linear dimensions be changed and what is the new R. F.?

13. A map 10 by 12 inches has R. F. =1/62500. What is the scale if the map be reduced to one-fourth its given size? If the length becomes 9.5 inches in reproduction, is the map enlarged or reduced? What is the new R. F.?

14. A map made to a scale of 1 in 10,000 is reproduced so that 800 yards on the ground scales 875 yards on the map. Was the map enlarged or reduced? In what proportion? What is the correct R. F. on the new map? Give directions for a correct reading scale.

15. The dimensions of a map with a R. F. of 1/63360 is 6 inches by 8 inches. What will be the dimensions of the map of a R. F. of 1/10560? How much is the area increased?

16. A sheet of drawing paper 17x22 inches is to contain a map of a region 8x7 miles, with a border of at least 1 1/2 inches. What is the largest scale that can be used?

INTENSITY OF MOONLIGHT.

With perpendicular incidence from an unclouded sky the intensity of sunlight is about 10,000 candle feet. The corresponding illumination from the full moon is approximately .02 candle foot. Thus the range of illumination between sunlight and moonlight is of the order of 1 to 500,000.

HOW TO BURN BITUMINOUS COALS ECONOMICALLY.

In order that there shall be the greatest economy in the burning of bituminous coals for heating the different federal buildings throughout the country, the Bureau of Mines, Department of the Interior, has conducted a series of tests with some of the widely used bituminous coals and has printed recommendations based on these tests. Fortunately, the recommendations will also apply to those having charge of private buildings and apartment houses.

The results of the tests are printed in Technical Paper 180, *Firing Bituminous Coals in Large House-Heating Boilers*, by S. B. Flagg. The recommendations on how to burn bituminous coals economically in these large house-heating boilers are as follows:

1. In burning bituminous coals in large house-heating boilers, the fuel bed should not be seriously disturbed until the coal has become well coked, that is, until the gassy part of the coal has been largely driven off.

2. Both caking and noncaking types of coal may be used satisfactorily in boilers of this type if properly handled.

3. The presence of a moderate proportion of screenings mixed with the lump coal causes the fresh charge of coal to heat more gradually and the emission of smoke is kept down more easily. Therefore, such a proportion of screenings is an advantage.

4. Increasing the proportion of screenings in the coal necessitates the use of a stronger draft in order to carry the same load. Smaller firing charges must also be used and more frequent attention given. The tendency of caking coals to cake is increased and this also means that the fire must have more frequent attention.

5. One large charge of coal fired by the spreading method will result in a longer emission of dense smoke than the total emission of such smoke from two charges of half the size fired some time apart and by the alternate method.

6. With some coals, moderate charges fired by the alternate method necessitate less frequent attention to the heater than larger charges fired by the spreading method. Caking coals having a considerable proportion of fine coal or screenings are usually among these. Conversely, a fire will usually require more frequent attention when a lumpy, caking coal, free from screenings, or a noncaking coal, is fired in moderate charges by the alternate method.

7. The number of tests made was not large enough to justify conclusions regarding the relative efficiency with which a coal may be burned by the two methods of firing, but the author believes that in actual service over considerable periods better results will be obtained by the alternate method.

8. Frequency of cleaning the fires will be determined by the character of the coal and the rate at which it is burned, but with most coals the fires should be cleaned only once or twice in twenty-four hours in ordinary weather.

9. If the alternate method of firing is employed, the cleaning should be done just before firing the fresh charge, and only one-half of the grate cleaned at a time. Then little or no smoke will result from the cleaning, because the side of the fire on which there is uncoked coal is not disturbed.

10. All three of the coals fired by the alternate method in the tests described were burned at rates corresponding to the heating conditions during the most of the winter, with scarcely any manipulation of the fuel bed except the cleaning of the fires and an occasional leveling just before firing.

11. The average fireman is apt to poke and slice the fire much more than is actually necessary. If a caking coal is used and the caked fuel must be broken up before it is well coked, slice the fire by running a straight bar under the fuel bed and raising it slightly so as to crack the caked mass. Do not stir the bed upside down by raising the bar through the fuel bed, nor break the bed with a bar from the top.

12. If the fuel bed is covered with a charge of fresh fuel in a layer more than five inches thick, the new charge, unless it is very free from slack, is apt to have a smothering effect. Then the output of the boiler will be correspondingly decreased and, especially if the spreading method of firing is employed, the mass of fresh coal will usually have to be broken once or twice before the fire will pick up. Consequently, the maximum firing charge should not be much thicker than five inches, and for caking coals containing considerable slack it should not be more than four inches thick. Of course, when a fire is to be kept banked, heavier charges may be used.

13. Do not fire large lumps of coal. Break all lumps into pieces no larger than fist size.

14. Large house-heating boilers do not require an intense draft to meet any reasonable demands for heat if the fuel bed is kept in proper condition, but the draft must be properly controlled.

15. The damper regulator should work freely with changes in steam pressure and should close the swinging draft opening in the ash-pit door before it starts to open the check draft in the smoke pipe.

16. The doors on the front of the boiler should fit snugly in their seats; special care should be taken to prevent any material wedging between the doors and the front and thus admitting air when or where it ought to be prevented from entering.

17. Do not allow clinkers to accumulate in the fire or too great a quantity of ashes on the grates. Be careful, however, in shaking the grates not to shake through unburned fuel.

18. In ordinary or severe weather keep an active fuel bed averaging ten to twelve inches deep. In milder weather the depth of active fuel may be decreased by keeping a layer of ashes on the grate under the live coals.

19. Keep ashes removed from the ash pit.

20. Keep flue surfaces clean by brushing at least once a week.

Copies of this technical paper may be obtained free of charge by addressing the Director of the Bureau of Mines, Washington, D. C.—[*Bureau of Mines*.

SULPHUR IN ALASKA.

The known sulphur deposits of Alaska are of volcanic origin and lie in the belt of active volcanoes that extends through the Aleutian Islands and Alaska Peninsula. The deposits on Unalaska and Akun Islands and near Stepovak Bay, on Alaska Peninsula, were examined in the summer of 1917 by A. G. Maddren, of the United States Geological Survey, Department of the Interior. The examinations showed that though there is some sulphur at each place examined there is little hope that any of it can be profitably mined at present or in the near future, for the deposits are of small areal extent and are probably shallow, supplies and labor are not at hand, the open season is short, the difficulties of transporting the material from the mines to ships would be great, and the haul to the larger markets would be long. A brief summary of the more important results of the investigation of these deposits has been published and will be sent on application to the Director of the Geological Survey, Washington, D. C.

GRAPHICAL ALGEBRA AS APPLIED TO FUNCTIONS OF THE n th DEGREE.

BY FRANCIS E. NIPHER,
Washington University, St. Louis, Mo.

A paper is about to be published by the Academy of Science of St. Louis, with the above title. I present here a somewhat different discussion, which leads to the same results. The difference between the area of two squares, whose sides have a length y and x, is

$$y^2-x^2 = y(y-x)+x(y-x) \tag{1}$$

The two terms of the second members represent the two rectangles marked a and b in the upper diagram of Figure 1.

If the lengths of the horizontal sides of these squares are increased from y and x to y^2 and x^2, we have the rectangles in the lower diagram of Figure 1. This can be done by laying off from the origin in the upper diagram any distance which is to be

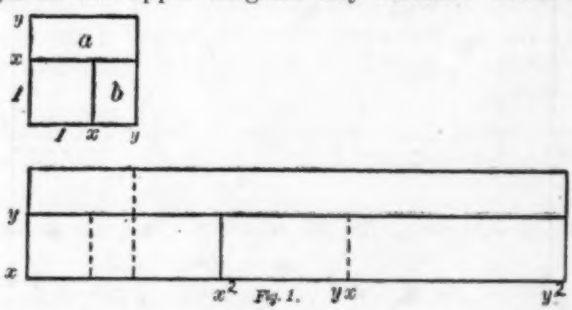


Fig. 1.

adopted as the unit. Draw a line through the point marked 1 on the vertical axis to the point marked x on the horizontal axis. A line parallel to this line through x on the vertical axis will intersect the horizontal axis at a distance x^2 from the origin. Laying this distance off upon the vertical axis, the distance x^3 may be determined.

$$\frac{1}{x} = \frac{x}{x^2} = \frac{x^2}{x^3} \text{ etc.}$$

In this extension of the sides of the two squares to form the new areas, y^3 and x^3, the value of $y-x$ of the first term of Equation (1) has not been changed. The multiplier in this term has been made y times as great. The term has become $y^2(y-x)$. In the second term, the value of the multiplier x has not been changed, but the values y and x in the factor $(y-x)$ have been changed to y^2 and x^2.

As thus modified, Equation (1) becomes

$$y^3-x^3 = y^2(y-x)+x(y^2-x^2) \qquad (2)$$

The value of y^3-x^3 may be developed by dividing it by $y-x$ and multiplying the resulting terms by $y-x$. In this way we have

$$y^3-x^3 = y^2(y-x)+y\ x(y-x)+x^2(y-x).$$

This equation can be readily changed to Equation (2). The value of yx can be determined by the method of similar triangles as above explained. If now the vertical dimensions in Equation (2) be changed, by multiplying by y and x as before explained, that equation becomes

$$y^4-x^4 = y^2\ (y^2-x^2)+x^2(y^2-x^2) \qquad (3)$$

The two squares $y^2 \times y^2 = y^4$ and $x^2 \times x^2 = x^4$ are shown in Figure 2.

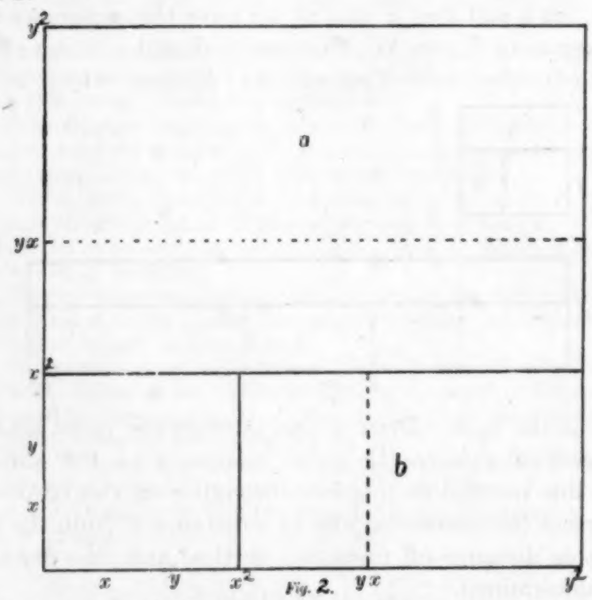


Fig. 2.

The two terms of Equation (3) are there shown to be the two rectangles marked a and b.

Equation (3) may be written

$$\begin{aligned} y^4-x^4 &= y^3(y-x)+y^2x(y-x) \\ &\quad +y\ x^2(y-x)+x^2(y-x) \\ &= y^2(y^2-yx)+y^2(yx-x^2) \\ &\quad +x^2(y^2-yx)+x^2(yx-x^2) \qquad (4) \end{aligned}$$

Equation (4) readily reduces to Equation (3). The first two terms of Equation 4 represent the area a. The dotted line marks the boundary between the areas represented by the first two terms of Equation (4).

This operation may be continued indefinitely.

The values of $y^n - x^n$ may be represented by areas, whatever the value of n may be. The area, $y^{10} - x^{10}$, may be laid off upon a lawn, by means of white strings, attached to stakes which mark the corners of the various rectangles. If $y = 5$ cm., and $x = 3$ cm., the outer square will have sides 3125 cm. in length.

APPARATUS FOR DETERMINATION OF THE THERMAL COEFFICIENT OF EXPANSION OF GASES.

By W. R. Goddard,

Polytechnic High School, Riverside, Cal.

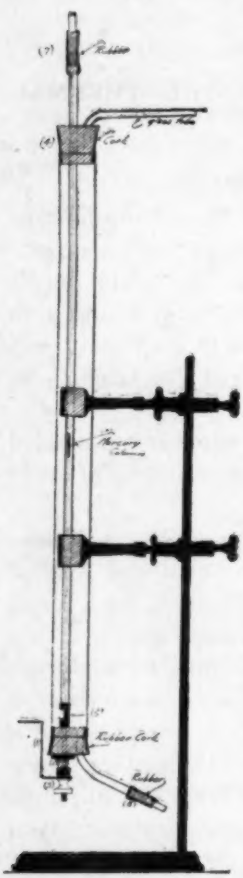
It is sometimes desirable to demonstrate the determination of the coefficient of thermal expansion of gases with a degree of accuracy which will not require an explanation to the pupils of the sources of error, which if taken into account would give the value as given in their textbook. Such an experiment may be performed with an apparatus arranged like the following:

The figure represents clearly enough what supplies are needed to make it, but a few explanations of the construction of some parts of it will be given.

The capillary tube is about 70 cm. long and has a 1 mm. bore. This is thoroughly cleaned with nitric acid and washed first by drawing a small piece of wet cloth back and forth, then rinsing well with distilled water. It is then attached to a suction pump and air which is dried by bubbling through concentrated sulphuric acid is drawn through while a bunsen flame is played along the tube. When it is thoroughly dry the tube is sealed off about two inches from the end toward the suction pump. While the tube is still hot it is disconnected from the sulphuric acid drying bottle, and a small globule of clean *dry* mercury is quickly placed on the opening. It will be drawn slowly into the tube as the dry air in the tube cools. The mercury globule is then forced about half way down the tube with a fine iron wire which lets the air out as it goes down.

The capillary tube of dry air is then placed in a larger tube about 4 cm. in diameter and 62 cm. long. The upper cork (4) is bored so as to easily slide up and down on the capillary tube without raising it. A two-holed rubber stopper is at the bottom. It contains an outlet tube and a brass cylinder (5) with an open side. The capillary tube is inserted. The open

side affords a view of the lower end of the air column. The brass cylinder is made by boring out a piece of brass rod and filing out the opening. It is held in place by a brass rod which is screwed into the bottom and extends about an inch and a half through the stopper. A washer and nut on the outside holds the cylinder in place and makes the connection water-tight. The zero point is located by a piece of double bent sheet brass (1) soldered to a brass guide as shown. The zero point is made level with the lower end of the air column by the thumb screw (3) and held rigid by the brass spring (2).



The operation of the experiment is simple. First set the zero point level with the lower end of the air column. Take off the upper plug (7) from the capillary tube and see that the lower delivery tube (5) is plugged. Raise the upper cork (4) and fill with finely crushed ice up to the mercury bead. After a few minutes place a meter stick on the zero level and read the initial volume of air (as length). The initial temperature is then zero degrees. Next remove the plug from the lower delivery tube and connect the upper inlet tube to a source of steam supply. Allow the steam to run through. The ice will melt and run out into a convenient receptacle.

When the mercury bead has risen to its highest point and remains stationary, again place the meter stick on the zero level and read the final volume. The final temperature is then calculated as the temperature of steam at the pressure read from a barometer. (2.68 cm. change in barometer reading makes a change of 1°C. in the boiling point of water.)

The calculation of the coefficient of expansion is then made exactly as in the case of linear expansion of metals, using the formula $e = k\ l(t'-t)$, where $t'-t$ is change in temperature, e is

expansion, k is coefficient, l is length—and substituting in the formula V for l.

Then if it is desired to demonstrate Charles' Law we have only to substitute in the Charles' Law formula, changing the temperature from Centigrade to absolute degrees. Or one may develop the formula from the data obtained.

The following data was obtained by the use of the above apparatus and subsequent trials gave the same readings for the initial and final volumes under the same conditions:

Initial volume of air	24.3 cm.
Final volume of air	33.2 cm.
Change in the volume of air	8.9 cm.
Initial temperature	0°C.
Final temperature	99.5°C.
Change in temperature	99.5°C.
Coefficient of expansion $k = \frac{e}{L(t'-t)}$	.00368

PROJECTS IN BIOLOGY.

By Grace F. Ellis,
Central High School, Grand Rapids, Mich.

The interesting article on "Projects in Biology" in the April number of School Science suggested to me that possibly some of your readers might find the following outline of work on the same subject of interest. It is used in classes of physiology in the tenth grade, and a hundred students are now at work at it. The general outline is supplemented by whatever project the student is most interested in, and he may prove his points in the discussion which is outlined, by reference to any project carried on by his fellows. I have used most of the experiments outlined in the article and find them satisfactory and interesting to students. In the final summing up of the work in this subject I shall use the excellent list of lantern slides put out by the Chicago Biological Supply House. I wonder if your readers know it?

Exercise XXV.

Problem: How are bacteria distributed?

Material: Sterilized dishes containing agar for cultures.

Directions: In every experiment count the number of bacteria and mold colonies which appear. Each colony of bacteria grew from a single bacterium. Colonies of bacteria are round, waxy-looking spots. Molds show spores and tiny fibers. When you open your dish notice whether the bacteria and molds have in any way affected the agar.

I. Does dust contain bacteria?

1. Collect a little dust from floor or furniture on a bit of stiff paper and blow it over the surface of the agar in a petri dish. Close the dish at once, seal the dish and cover together, and mark with your name, date, and material.

2. Mount a little dust in water on a glass slide, cover and examine under high power. What does it consist of so far as you can tell? Does it seem to offer a lodging place for germs? To answer this question, mounts of silk, cotton, and woolen fibers and dirt are provided.

II. Do bacteria float in the air?

1. Expose a prepared bacteria dish for two minutes to the air

of a room. Close, seal, and label as above. The room may be one of the school rooms, or a room at home or in some public building.

2. Compare air in a room with unoiled floor recently swept by a broom; with vacuum cleaning; with one in which sweeping of an oiled floor is being done.

III. Do bacteria exist in the body?

1. Place a measured amount of saliva in a bacteria dish. Seal and label.

2. Scratch a finger nail across the agar and seal your dish.

Written Report.

Use ruled paper, leave margin, use numbers or headings, and report in connected theme form, on the problem which forms your subject.

I. Introduction.

Preparation. Explain how the culture medium and dishes are prepared and why so much care is taken to sterilize everything that is used.

II. Exposure.

How are the cultures exposed to the air and to dust? What does dust seem to be under the microscope? Might dust harbor germs? Is dust dangerous?

III. Results.

Which cultures yield more bacteria, dust or air? What makes the difference in this building (i. e., presence of more bacteria in air or dust)? How should this knowledge affect our treatment of floors in public buildings? Our methods of cleaning? Do you believe in the use of a feather duster? Why?

IV. Bacteria in the body.

Do you find bacteria present on the skin? In the mouth? Are these dangerous? May the mouth harbor dangerous bacteria?

V. Bacteria and disease.

Do coughing and sneezing have anything to do with their distribution? Why are colds contagious? Can you suggest any means of reducing the number of bacteria in the mouth? Why are the nose and throat so often infected?

BACTERIA[1]

By Mary Wilde,

Grade 10-1, Central High School, Grand Rapids, Mich.

I. Introduction.

(*a*) *Preparation.*—The culture medium which was used was agar, a Japanese seaweed which is a jelly-like substance. This substance was heated until it had thoroughly dissolved; about six hours was necessary for this to take place. The bacteria dished into which this was immediately poured, so that no bacteria could possibly enter, were baked in an oven three times at intervals of twenty-four hours, so that all germs might be killed with the excessive heat. Great care was taken that no fingers touched this, or that breath reached it, so that no germs could possibly enter and that the agar might be absolutely free from germs.

II. Exposure.

(*a*) *Cultures Exposed to Air and Dust.*—The cultures are exposed to air by leaving them open two minutes, and to dust, by quickly lifting the cover of the dish and blowing in the dust or any other substance with

[1]This is one of the results of the project plan as outlined by Grace Ellis on page 607.

which you are experimenting. Looking at dust under the microscope it looks to be little particles of dirt and fibers. Dust harbors many germs as I proved with my experiment. For this reason great care should be taken that dust be kept down on the floor instead of flying around in the air. It is my opinion that dust is dangerous, for very likely it carries disease germs.

III. RESULTS.

(a) *Methods of Cleaning.*—Dust yields much more bacteria than air, for dust collects on furniture and the like, while air is continually moving. This building has a very small amount of bacteria in the air, for an oily preparation is poured on the floor before sweeping, thus keeping the dust from flying around on other articles and in the air for us to breathe. A vacuum cleaner is the very best article used for cleaning, for it not only collects more dust in the rugs than a broom, but also takes up the dirt so quickly that very little dust collects on the furniture; therefore, it has the same effect on the air that the oil on the floors does. I do not believe in the use of a feather duster, for the dust only flies from one article to another and so of course a great deal of dust is flying around and after one is through dusting the question is asked, "Have you dusted yet"? This is very discouraging.

IV. BACTERIA IN THE BODY.

(a) *On the Skin and in the Mouth.*—Bacteria are present on the skin and in the mouth, as was tested in the laboratory. The bacteria which are found in the mouth are very dangerous, for they may develop dangerous disease germs such as diphtheria, typhoid, and scarlet fever. With diphtheria the bacteria are mostly in the throat. This disease is more common to children than to grown people, for children are more liable to exchange handkerchiefs, pencils, gum, and the like. Typhoid fever is a disease which is caused only by eating or drinking the typhoid germs. These typhoid germs are found in unfiltered water in Grand Rapids; therefore, it is necessary that the water people drink be absolutely pure.

V. BACTERIA AND DISEASE.

Coughing and sneezing with mouth or nose uncovered has a great deal to do with their distribution, for by means of these the germs in the mucus fly to the nearest person, who usually begins to sneeze and before a great while has developed a cold. Colds are contagious, for in coughing and sneezing the germs are spread and many persons are thereby affected. The nose and the throat are very often infected, for by an experiment which was made with a soiled handkerchief and agar, many bacteria are found to reach the nose. Also, an unsterilized toothbrush was given the same treatment with the agar that the soiled handkerchief was, and this also grew many bacteria. In this way the mouth and throat become infected.

VI. THE BACTERIA EXPERIMENTS.

To me, there were a great many very interesting experiments about which I would like to tell, but there are too many to mention them all. I think the most interesting was the experiment of agar exposed to the air in a theater. After this had been kept long enough to allow bacteria to develop, if present in it, a great many bacteria had grown. Moral: Do not go to a theater unless you are physically able to kill the bacteria which may enter your body.

VII. CONCLUSIONS.

(1) Have clean habits.

(2) Do not drink unfiltered water, that the chance for typhoid fever may be less.

(3) Sterilize your toothbrush, that your mouth may be as free from germs as possible.

(4) Do not use soiled handkerchiefs, that your nose and throat may be kept free from germs.

(5) Keep physically strong and healthy, as this is "the first service that you owe your country."

AMERICAN NEEDS FOR ENGLISH CLAY.

Most of us think clay is something as common and abundant as sand or gravel. Consequently, it comes as a surprise to be told by the Shipping Board Committee on Mineral Imports and Exports in Washington, that even in this day of great shortage of oceangoing ships we have to import from England every year 200,000 to 250,000 long tons of clay. Last year we imported more than 250,000 tons over the ocean.

Furthermore, a great part of this clay comes over in steamers loaded full and the rest in big steamers loaded with clay up to fifty per cent and more of their maximum carrying capacity. These ships put into Fowey, England, for their freight. To get this clay on and off the boats requires ten days on each cargo. An insignificant percentage of the clay is shipped as ballast. This represents small lots loaded into big liners at Liverpool. But it will be seen that the importation of English clay consumes an important amount of ship tonnage measured in days' time lost because of natural delays incident to the transport of this freight.

Why do our manufacturers pay the high freight rates now necessary in order to obtain an article like clay from England? There is, as we all know, an abundance of clay in this country. A great deal of high-grade clay is produced here, and of a character suitable for pottery, porcelains, and other articles which require clays of special excellence in their manufacture. But not much over half of the clay of this grade that our industries require is domestic. When war broke out in 1914, only a third of it was domestic. We have not been able to develop and equip our deposits fast enough to make these English clay imports unnecessary. In fact, it is doubtful whether we will produce as much high-grade clay in 1918 as we did in 1917. Our manufacturers want the clay, but they cannot get anywhere near as much as they want. The reduced output is due to railroad and operating conditions and is not related to the character or size of the deposits, which are capable of large production.

Domestic producers do not mine their clay quite as cleanly as their English competitors. Nor is the domestic clay as uniform in character. It will not bring the high prices paid for English clay. But more could be sold if it could be produced and carried to its market. Still more could be marketed if cleaner, more uniform clay were produced, for in that event the consumers would use a greater percentage of domestic and correspondingly less English clay in their mixtures.

However, our complete dependence upon English clay continues. We must rely on English clay as a chief ingredient of the dishes we eat from, the paper in our books and magazines, the porcelain in our electric light sockets and half a dozen other articles of less general use.

Fortunately, it is a fact that far less English clay is necessary to proper manufacture of paper than is now used. Besides domestic clay there are many other substances of domestic origin that could be used in the body, not the finish, of this paper. Over half of the English clay we use is consumed in making paper. So that, if a shortage of English clay should develop, it would not be highly serious until the shortage became very great, until there was only half of the normal supply, or less, available.

MOCK TRIAL OF B VERSUS A, OR SOLVING A PERSONAL EQUATION BY THE JUDICIAL PROCESS.

ADAPTED BY KATHRYN MCSORLEY, HUNTER COLLEGE, FROM MR. STEPHEN LEACOCK'S STORY, "A, B, C."

CHARACTERS.

JUDGE. Man of few words. Speaks briefly and shows no unusual interest in the proceedings.

OFFICER OF COURT. Pompous, feels very important, repeats, demands of judge in ringing tones.

FIRST AND SECOND LAWYERS. Fussy but businesslike, each bound to win the case.

A. Very much alive, great interest in what is going on, with a tendency to bet with second lawyer whenever an opportunity presents itself. A full-blooded, blustering fellow of energetic temperament, hot-headed and strong-willed.

B. A quiet, easy-going fellow. Afraid of A and bullied by him, and quite in A's power having lost all his money in bets. He has gentle, tender thoughts of little C.

D. A tottering old man, inclined to be talkative and tell a great deal more than is asked. Completely at sea when second lawyer fires his volley of technical language, but when first lawyer shows his friendliness he is very eager to please him and tell all he knows.

COURT CLERK.

JURY. Plane Trigonometry, Arithmetic, Algebra, Plane Geometry, Solid Geometry, Spherical Geometry, Differential Calculus, Integral Calculus, Descriptive Geometry, Astronomy, Spherical Trigonometry, Analytics.

(*Judge's stand and desk are up center of stage. Seats for the jury are placed left of the judge. Can put seats for newspaper reporters at right. In front of judge's stand is a table with books, documents, etc., for the attorneys and clerk. A witness stand and a prisoner's box, one right and one left. Court clerk sits at lawyer's desk ready to take notes.*)

(*Officer of the court bows in the judge.*)

Officer—This way, your Honor!

Judge—That will do. (*Goes to desk.*) Go ahead and cry.

Officer—(*Shouts.*) Hear ye! Hear ye! The court is open, for his Honor is here.

(*Enter on the right first lawyer—tall, lean, with books and papers. Collides with officer.*)

First Lawyer—Beg pardon, I'm in a hurry. (*Goes to the table in front of judge's desk.*)

Officer—If I had bitten my tongue off that time, I'd give you a piece of my mind.

(*Enter second lawyer—another fussy lawyer. Goes to table.*)

Judge—(*Raps.*) Call in the jury from the juryroom.

Officer—(*Calls from list.*) Plane Trigonometry!

(*Enter Plane Trigonometry.*)

Judge—What is your occupation?

Plane Trigonometry—I am a dealer in triangular sines by profession, but largely famous for my tables.

Judge—So you make signs and tables for money?

Plane Trigonometry—No, your Honor, I make tables of sines for articles of torture in the hands of some instructors and for the annoyance of freshmen.

Judge—Go sit down among the jury. Call the next juror.

Officer—Arithmetic!

(*Enter Arithmetic with example of galley method in evidence.*)

Judge—Are you a married man?

Arithmetic—No, Judge, all these scratches come from an old habit of division I can't quite control.

Judge—You have been summoned to be a juror. Do you know the nature of an oath?

Arithmetic—I do, your Honor.

Judge—Give me an example.

Arithmetic—You beast, you dog, you algorismus cipher, you—

Judge—(*Raps.*) That is enough, go sit down among the jurors. Next juror.

Officer—The next calls himself Algebra.

(*Enter Algebra.*)

Judge—What is your occupation?

Algebra—I search the unknown and help solve the most perplexing problems for those who employ me.

Judge—Do you mean that you are a detective?

Algebra—Well, your Honor, I would not call it exactly that. By the same process of reasoning I would be a dentist, for I have the extraction of roots down to a science. But I *am* a person of Harmonical Proportions, vitally concerned in Progression.

Judge—All right. If the lawyers have no objection, sit down. Officer, hurry them along.

Officer—Geometry!

(*Enter the three Geometries—Plane, Solid, and Spherical.*)

Solid Geometry—We are three, your Honor, Plane. (*Introducing Plane Geometry.*)

Plane Geometry—I am wont to wander about in circles or go off on tangents, but I am usually on the square.

Solid Geometry—(*Introducing other companion.*) Spherical—and myself, a man of substance, a solid citizen—of no particular profession. In the realm of mathematics, however, we might be said to hold a place proportional to that of a conductor of a newspaper society column. We concern ourselves not only with the measurements of magnitudes, but with their various properties and relations as well. We are the personification of logic itself, and follow every hypothesis with a proof, the genuineness of which is established by the addition of my usual signature, Q. E. D., or that of my secretary, Q. E. F.

Judge—That will do. Take your seats among the jury.

Officer—That reminds me, your Honor, we have three jurors sworn in since yesterday. (*Calling.*) Descriptive Geometry, Differential and Integral Calculus. Take your places among the jury. (*These three enter and take seats.*)

Judge—Hurry them in.

Officer—Astronomy!

(*Enter Astronomy.*)

Judge—Have you a profession?

Astronomy—Before the war broke out, your Honor, I dwelt among Hunter students, and entertained them with stories of my travels along the cyclic path and tales of the heavenly bodies I met there. I described their appearances, determined their magnitudes, and explained the laws which governed their motion. But political conditions on this planet have disturbed my power to concentrate on the universe, so I am stopping at the Southern Cross, where I teach the Geography of the Heavens, and Methods of Tracing the Stars.

Judge—Sit down. Next juror.

Officer—Enter Spherical Trigonometry.

(*Enter Spherical Trigonometry.*)

Judge—What do you do?

Spherical Trigonometry—I am general assistant in the firm of Practical and Nautical Astronomy.

Judge—Sit among the jury. Next.

Officer—(*Shouts.*) Next!

Judge—Who are you?

Analytics—Your Honor, to be frank, I am appearing under an assumed name. I came into the world as Geometry, but in my youth I came under the dominion of Algebra. Her influence was

a good one. I grew in strength and finally reached such a state of independence that we considered it wise to assume a new name, Analytics, that my present status might be recognized. I am both *plane* and *solid.*

Judge—Sit among the jurors.

Officer—The jury is all here, your Honor.

Judge—(*Raps.*) Order in the court. The jury is sworn to render a verdict according to the evidence. Do you swear?

Jury—(*Shaking heads.*) Not aloud.

Judge—We are now ready for the trial.

First Lawyer—I represent the plaintiff.

Second Lawyer—And I appear for the defendant.

Judge—Call the plaintiff.

Officer—Let the plaintiff, B, enter.

(*Lead B and his friend D in to witness side of room.*)

Second Lawyer—Your Honor, my client is ready to proceed when you are.

Judge—Bring in A.

Officer—Bring in the defendant. (*Conduct A to chair on jury side of room.*)

Judge—Is this jury satisfactory?

First Lawyer—(*Confers with his client.*) It is to our side.

Second Lawyer—(*Same business.*) And satisfactory to us.

Judge—(*To jury.*) Gentlemen of the jury, you will render a verdict in the case of B versus A, the defendant, whom he charges with the death of C, their partner, and sues for a share of A's profits in accordance with the law of Arithmetical Progression.

First Lawyer—May it please your Honor, and gentlemen and ladies of the jury, I present my case to you. The men involved are not unknown to you. You have followed their history through countless pages of problems. It is a long time since you were told, "A, B, and C can do a certain piece of work. A can do as much in one hour as B in two, or C in four. Find how long they work at it." Or thus, "A, B, and C are employed to dig a ditch. A can dig as much in one hour as B can dig in two, and B can dig twice as fast as C. Find how long, etc., etc." Or after this wise, "A lays a wager that he can walk faster than B or C. A can walk half as fast again as B, and C is only an indifferent walker. Find how far, and so forth."

The occupations of these men are many and varied. In the older arithmetics, they contented themselves with doing a

"certain piece of work." This statement of the case, however, was found too sly and mysterious, or possibly lacking in romantic charm. It became the fashion to define the job more clearly and they set themselves at walking matches, ditch-digging, regattas, and piling cord wood. At times they became commercial and entered into partnership, having with their old mystery a "certain" capital. Above all they reveled in motion. A rides on horseback, or borrows a bicycle and competes with his weaker associates on foot. They have raced on locomotives, they have rowed, or again they have become historical and engaged stage-coaches, or at times become aquatic and swam. If their occupation was actual work, they preferred to pump water into cisterns, two of which leak through holes in the bottom and one of which is water-tight. A, of course, had the good one. He always took the bicycle and the best locomotive, and the right of swimming with the current.

Whatever they did, they put money on it, being all three sports. And A always won.

You will notice A is a blustering fellow, hot-headed and strong-willed. It was he who proposed everything, challenged B to work, made the bets, and bent the others to his will. He is a man of great physical strength and phenomenal endurance. He has been known to walk forty-eight hours at a stretch and to pump ninety-six. He has bullied B and C, kept them in his power, having won all their money in bets. He enslaved them and ruined their health. He finally exterminated C with his endless betting and gambling. He drove the others, whose spirits were willing but whose flesh was weak.

May the law of Arithmetical Progression descend upon his head!

Let B, the plaintiff, take the stand.

B—Oh, dear, don't let him (*Gestures to A.*) start me piling up those papers or (*Hesitates.*) measuring the density of their heads. (*Reassured by lawyer, goes to stand.*)

Judge—The evidence you will give in this case will be the truth, or as much of it as you can tell?

B—(*furtive glance at A.*) Yes, your Honor.

Judge—What is your name?

B—B, sir.

Judge—Are you married?

B—Not now, sir. She died of worry, sir.

Judge—What is your age?

B—As well as I can remember, we were invented by some mathematicians, 1000 B. C.

First Lawyer—(*Encouragingly.*) Tell your simple story of wrong and suffering to the jury. Tell them how you and C were inflicted by the heartless wretch seated there.

B—I'll try—but—I have no heart for work and he is sure to start something. (*Looks on the verge of tears.*)

A—(*To second lawyer.*) I bet if he begins to cry, I can make twice as much noise as he can.

First Lawyer—(*Jumps up.*) Listen to him, your Honor, the gambler is betting again. After he has wheedled all he could from my client and the deceased C, including the life of the latter, he turns to the prolific source at his side. (*To B.*) Go on with your story.

B—It all began, that is, the end began one evening after a regatta. We had been rowing in it and it transpired that A could row as much in one hour as I could in two, or C in four. C and I came in fagged out and C was coughing badly. "Never mind, old fellow," I said to him. "I'll fix you up on the sofa and get you some hot tea." But A came blustering in and said, "I say, you fellows, Hamlin Smith has shown me three cisterns in his garden and said we can pump till tomorrow night. I bet I can beat you both. Come on. You can pump in your rowing things, you know. Your cistern leaks a little, I think, C." I said it was a shame, that C was used up now, but we went, and—(*Sigh.*) soon anyone could tell from the sound of the water that A was pumping four times as fast as C.

We never got any time to eat or sleep, and soon we couldn't keep at our accustomed tasks. Work in that line is now done by M, N, and O, and some people are now employing for algebraical jobs four foreigners called Alpha, Beta, Gamma, and Delta.

Poor C was an undersized, frail thing with a plaintive face. Constant walking, digging, and pumping had broken his health and ruined his nervous system. His joyless life had driven him to smoke more than was good for him. And his hand often shook as he dug ditches. He had not the strength to work as A and I did; in fact, as Hamlin Smith said, "A could do more work in one hour than C in four." But he wouldn't listen to me. But I can't go on (*Sob.*), it was all too heartless. (*Jury and officer all start into tears and sobs.*)

First Lawyer—Your Honor, and gentlemen and ladies of the

jury! This is the most heartless case of overwork within school doors that it has ever been my fate to hear of or be interested in. There is no money on earth or no punishment that can heal my client's bruised heart or atone for his loss in the person of little C for whom he always had a gentle, brotherly feeling. We seek some balm for this shattered heart—the arithmetical sum of a series of 500 terms beginning with 3 when the difference is 7—a mere bagatelle. That will not return one-half of my client's lost manhood and assertiveness. Yet we will take it—take it as a lesson to future mathematicians (*Gestures to audience.*) tempted to overwork those in their power. I ask you to shed tears for my client if you have any to shed. If you have none, think of the deceased. He (*Indicates B.*) has told you the solemn truth in all its harrowing details. To further substantiate the truth spoken by him, I call to the witness stand D, at one time affiliated in this partnership. (*D comes to stand.*) He will corroborate all the details so reluctantly given by B, my client.

(*Court clerk takes big book to D at the witness stand.*)

Clerk—Do you swear to tell the truth, the whole truth, and nothing but the truth?

D—Yes, sir.

Clerk—Put your hand on the book and say, "I do so swear."

D—(*Very awed, places hand on book.*) I do so swear.

(*Clerk returns to take notes.*)

Judge—What is your occupation?

D—I just scratch about in the garden, sir, and grow a bit of logarithm or raise a common denominator or two. But Mr. Euclid he use me still for them propositions, he do.

Judge—Do you realize the nature of an oath?

D—I've heard my father use them.

Second Lawyer—(*Arises.*) Your Honor, and gentlemen and ladies of the jury. I represent the much-maligned person A, alias John of "John, William, and Henry," alias x of "x, y, and z," my client. First I will cross-examine the witness. Do you know the defendant?

D—Do I know 'em, sir? Why, I knowed 'em all ever since they was little fellows in brackets. Master A, he were a fine lad, sir. Though I always said, "Give me Master B for kind-heartedness like." Many's the job as we've been on together, sir. Though I never did no racing or aught of that, but just the plain labor, as you might say.

Second Lawyer—(*quickly, with an aim at bewildering D.*)

Do you know any of the details leading up to this most infamous attempt at blackmail, coercion, and vilification?

D—(*Not comprehending.*) N-n-no, sir.

Second Lawyer—Has the plaintiff ever told you of the prospects he would have in case he sued said defendant in this court of appellate jurisprudence and legal acumen?

D—(*Still not understanding.*) N-n-no, sir.

Second Lawyer—Did you behold said manslaughter coming under the head of fatigé corpus, Sec. 2, pg. 45, state laws of jurisprudence, Littleton or Coke?

D—N-n-no, sir.

Second Lawyer—Nor would the actual occurrence, having taken place homicidal or technical, with malice or forethought, create a desire for his perpetual incarceration?

D—No, sir.

Second Lawyer—Your Honor, their star witness is on the stand. (*Mimic.*) Yes, sir; no, sir; no, sir. Gentlemen and ladies of the jury, is this evidence in a court of law? A child could have fathomed my legal phrases and meaning. (*To D.*) Did you comprehend the significance of my interpellations

D—(*With the same bewildered look.*) N-n-no, sir.

Second Lawyer—Do you speak French?

D—No, sir.

Second Lawyer—Do you speak German?

D—No, sir.

Second Lawyer—Do you speak Spanish?

D—No sir.

Second Lawyer—Do you speak Italian?

D—No, sir.

Second Lawyer—Do you speak Hindoo?

D—No, sir.

Second Lawyer—(*To jury.*) You will observe that I have addressed him in seven different languages and he can't understand one. (*To D.*) That is all. You may come down.

First Lawyer—(*Interrupts.*) Your Honor, I would like to question this witness.

Judge—Let this proof be brief and to the point.

First Lawyer—Were you not present at the melancholy end of your former acquaintance, C?

D—(*Face clearing up as he understands.*) Yes sir.

First Lawyer—Tell what you know.

D—Well, sir, A and B had been rowing on the river for a wager

and C had been running on the bank and then sat in a draught. Of course the bank refused the draught and C was taken ill. A and B came home.

First Lawyer—(*Interrupts.*) And found C lying helpless in bed?

D—Yes, sir.

First Lawyer—(*Questioning.*) A shook him roughly and said, "Get up, C, we are going to pile wood." C looked so worn and pitiful that B said, "Look here, A, I won't stand this. He isn't fit to pile wood tonight." Is this so?

D—Yes, sir, and C smiled weak like and said, "Perhaps I could pile a little if I sat up in bed."

First Lawyer—(*As a question.*) Then B, thoroughly alarmed, said, "See here, A, I'm going to fetch a doctor; he's dying"?

D—(*Humbly.*) Yes, sir, and A got mad, sir, and said they had no money to fetch a doctor.

First Lawyer—What did B do then?

D—He said, "I'll get a doctor. I'll reduce him to his lowest terms. That will fetch him."

First Lawyer—Yes, and then?

D—Well, sir, C's life might have been saved even then if it hadn't been for a mistake about the medicine. It stood at the head of the bed on a bracket, and the nurse accidentally removed it from the bracket without changing the sign.

After that blunder C sank rapidly. On the evening of the next day (*Melancholy.*) as the shadows deepened in the little room, it was clear to all that the end was near. I think even A was affected at the last as he stood with bowed head aimlessly offering to bet with the doctor on C's labored breathing. "A," whispered C, "I think I'm going fast." "How fast do you think you'll go, old man?" murmured A. "I don't know," said C, "but I'm going at any rate."

The end came soon after that. As his soul sped heavenward, A watched its flight with melancholy admiration, and B (*Sniffling.*) burst into a flood of tears. (*Sobs.*) We put away his little cistern and the rowing togs he used to wear and we, B and I, sir, we feel as if we could hardly ever dig again. (*Crying—deep sob.*)

(*Judge raps for order.*)

First Lawyer—That will do. Calm yourself. You may come down.

Second Lawyer—(*Jumping up.*) Oh, your Honor, and—I

came near forgetting—ladies and gentlemen of the jury, I want you to look in the face of my client. His life has been arduous and full of peril. A mistake in the working of a sum might keep him digging a fortnight without sleep. A repeating decimal in the answer might kill him, yet he was not deterred. He went right on betting and supplying arithmetics and algebras with page after page of problems. Now you will have a chance of showing your gratitude. Is he to be held accountable if C's strength was in inverse proportion to his own? Because he is a full-blooded, energetic fellow with much initiative, do you think he is without a heart, without emotions? Ah, you forget his panting sides as he pumped water four times as fast as C. You forget his eager counting of the last exhalations of the dying C. Did he not admit himself baffled by the rate and direction of the flight of C's soul? I have here a vector diagram of that same occurrence which he constantly carries with him to have for reference when his own soul flees. He is still confident that his soul will overtake C's before the former comes to rest. Did he not attend that little funeral so plain and unostentatious? Is this acting as a murderer? No! (*Ringing tone.*) but as a true sporting man and mathematician he engaged two hearses, one for himself and one for B. Both vehicles started at the same time, B driving the one which bore the sable parallelepiped containing the last remains of his ill-fated friend. A, on the box of the empty hearse, generously consented to a handicap of 100 yards, but arrived first at the cemetery by driving four times as fast as B.

As the sarcophagus was lowered, the grave was surrounded by the broken figures of the first book of Euclid.

It may be noticed that A has become a changed man, has lost interest in racing, and digs but languidly. He has given up work and settled down to live on the interest of his bets. Oh, your Honor, and ladies and gentlemen of the jury, look at my client. The learned legal brother is trying to get the sum of an arithmetical series from him as balm. Oh, again I say to you, this is a base conspiracy, and I rely on your sound judgment, and I feel sure that conspirators and blackmailers will fail in their attempt to extort money from my client. I am attending to that myself. (*Sits down and fans himself.*)

Judge—Gentlemen and ladies of the jury. You have heard the evidence on both sides. If you have a verdict for the plaintiff, let it be balm enough to revive his interest in mathematics.

If you find a verdict of acquittal on the charge of murder and extortion for the defendant, so let it be known.

(Silence in the court while the jury confers.)

(Jury files out of the room—in a very short time files back again, Chairman first. B weeps and A begins to bet with his lawyer on the length of time it will take the jury, etc. When jury is seated judge raps for order.)

Chairman of the jury—*(Arises.)* We have agreed upon a verdict—that is, I have, and the rest have come down to the same terms.

Judge—What is your verdict?

Chairman of the jury—Guilty, your Honor, in the *n*th degree.

Judge—In the eyes of the court, the problem through the proper reduction of radicals involves the personal equation such that A = B+C. C approaches infinity, through no fault of his own, leaving A and B to settle. B, in his charge of murder and extortion, has proved his claim, and A by his own *demonstration* has proved his intellectual quantities imaginary. Treat them both simultaneously. If A finishes before B, who will drink only half as fast, he will devote the rest of his term to determining the value of π, especially Omega and Nu π. The result is to be sent to Mr. Hoover and the Housewives' League.

(Exit judge, then jury, then the rest.)

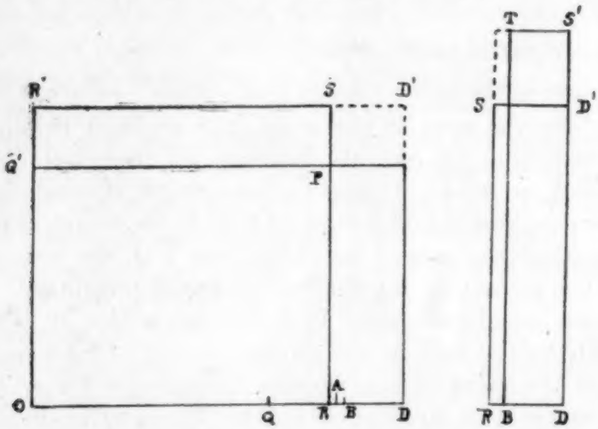
A GRAPHICAL REPRESENTATION OF APPROXIMATIONS FOR SQUARE ROOT.

By Otto Dunkel,
Washington University, St. Louis, Mo.

In the January, 1918, number of School Science and Mathematics a simple rule was given for approximations to any root of a number, and it was pointed out how any degree of accuracy could be obtained by successive applications of the rule. In this article it will be shown how the process can be represented graphically in the case of square root in a manner which exhibits the rapidity of convergence of the successive approximations and which also yields a test of the accuracy of each step. In the article referred to there is an inaccurate statement of the rough estimate of the number of decimals which could be depended upon, and this inaccuracy will be corrected below. It will also be shown algebraically how the method can be supplemented by certain corrections which yield additional correct figures.

If we suppose that r is the square root of the given number, then that number can be represented by the area of a square whose side is r = OR = OR′ as in the figure below.

If d is the number which we first try, or one of the numbers determined as an approximation by the rule, then the next approximation is obtained by dividing the given number by d and taking the average a of the quotient q and the divisor d. We shall suppose that d is larger than q. Thus d and q give the lengths of the sides OD and OQ′, respectively, of a rectangle



having the same area as the square and such that OD is larger and OQ′ smaller than the side OR of the square. The rectangle is shown in the figure placed upon the square so that the two have the right angle at O and the overlapping rectangle OP in common. It follows at once that the area of the rectangle R′P is the same as that of the rectangle PD. Add to each of these latter rectangles the small adjoining rectangle PD′, and it will be seen that the areas of rectangles Q′D′ and SD are the same. Since R′D′ is greater than D′D, it follows that Q′R′ is less than RD, and if we lay off on DR the length DB = Q′R′, the point B will fall within DR. Mark off also on OR the length OQ = OQ′ = q. The average a of OQ and OD is given by OA where A is the mid-point of QD and also of RB since QR = BD. Hence the average a = OA is greater than r = OR. It should be observed that this is a proof that the arithmetic mean of any two positive quantities is greater than their geometric mean, for it shows that $(q+d)/2 = a > r = \sqrt{qd}$.

The error in taking a as the root is the length RA, which will be denoted by e', while the error in d is RD, denoted by e_1, and

the error in q is QR, denoted by e_2. The figure gives a good idea of how much smaller e' is than either e_1 or e_2. Only in case of a selection of d obviously too large can e' be greater than e_2. We shall now obtain from the figure a very useful relation between e' and e_1 which enables us to test the accuracy of the approximations at each step. The figure to the right shows the rectangle RD′ with the rectangle Q′D′ placed upon it in the position BS′ so that Q′R′ coincides with DB. Since these two rectangles have equal areas the area of the thin rectangle SB is equal to that of the rectangle TD′, which is almost square, lacking only ST to be a complete square. Adding then the little rectangle ST to each of the rectangles SB and TD′ we have the final result that the rectangle RT and the square SS′ have equal areas, i. e., $RB \times BT = SD'^2$, or, since $RB = 2e'$, $BT = d$ and $SD' = e_1$,

$$(1) \qquad e' = \frac{e_1^2}{2d}, \quad \text{where } e' = a-r,\ e_1 = d-r.$$

This shows how rapidly the error decreases from one approximation to the next. For example, if d is correct in the first three decimals, then $e_1 < .001$ and hence $e' < .0000005/d$ so that a will be correct in six decimals, or more if d is much larger than 5. Thus we may state the rough rule that the correct number of decimals in any approximation is in general twice the number in the preceding approximation.

In a similar manner it may be shown from the figure that

$$(2) \qquad e' = \frac{e_2^2}{2q}, \qquad e' = \frac{e_1 e_2}{2r}, \quad \text{where } e_2 = r-q,$$

and with a little more trouble but in an analogous manner that

$$(3) \qquad a-r = e' = \frac{h^2}{4(a+r)}, \quad \text{where } h = d-q.$$

This last result may also be obtained by combining the equations in (1) and (2). Since $a > r$ and $r > q$ we deduce from (3) the inequalities

$$(4) \qquad \frac{h^2}{8a} < e' < \frac{h^2}{4(a+q)},$$

which are more convenient as tests of accuracy than the others since we always know h. To illustrate the use of these inequalities, let us approximate $\sqrt{3}$ by taking first for d the value 2; we find mentally that $q = 1.5$ and $a = 1.75$. Applying the rule again and taking now $d = 1.74$, since 1.75 is too large, we find

that $q = 1.7241379310$ and $a = 1.7320689655$. Computing roughly the value of the expressions in (4) we find that $.0000181\dot{5} < e' < .000018199+$, and, reducing a by the smaller number, we have 1.7320508 as correct figures of the root. This shows how we may use the expression to the left in (4) as a correction in order to obtain more correct figures, or, in other words, that

$$a - \frac{h^2}{8a} \tag{5}$$

is a better approximation to r than a. It may be seen from what follows that (5) gives really more correct figures than were indicated above, in fact, we may use ten decimals of the correction $.000018\dot{1}\dot{5}79$, thus obtaining as correct figures of the root 1.7320508076.

It is possible to find a second correction, a third, and so on, but it is not so easy to do this graphically, and so we shall proceed algebraically. The error in (5) is

$$a - \frac{h^2}{8a} - r = (a-r) - \frac{h^2}{8a},$$

which may be factored by replacing $(a-r)$ by its value in (3) and reduced further by the same substitution, thus

$$\frac{h^2}{4(a+r)} - \frac{h^2}{8a} = \frac{h^2(a-r)}{8a(a+r)} = \frac{h^4}{32a(a+r)^2}.$$

Hence we have

$$\frac{h^4}{128a^3} < a - \frac{h^2}{8a} - r < \frac{h^4}{32a(a+q)^2} \tag{6}$$

The expressions on the right and left of the inequality sign do not differ greatly and hence we may use the one to the left as a second correction. We obtain in this way the still better approximation

$$a - \frac{h^2}{8a} - \frac{h^4}{128a^3}. \tag{7}$$

By subtracting r from this expression, and factoring and reducing as before in order to find the error, we shall find a third correction and the approximation,

$$a - \frac{h^2}{8a} - \frac{h^4}{128a^3} - \frac{h^6}{1024a^5}. \tag{8}$$

The reductions become troublesome when we proceed much further in this way, but by the use of the binomial theorem for fractional exponents all of these terms and as many more as may

be desired may be easily obtained. For we have only to write the equation (3) in the form $r^2 = a^2 - h^2/4 = a^2(1-h^2/4a^2)$, or $r = a(1-h^2/4a^2)^{\frac{1}{2}}$, and expand the second factor in order to obtain the above development. This development by the binomial theorem will yield very easily any number of terms, but it depends upon the demonstration of the validity of the binomial theorem for fractional exponents, and this demonstration is quite difficult. But for any ordinary computation only one or two of the correction terms would ever be needed since they diminish very rapidly when h is small, as in the computation of $\sqrt{3}$ above, and in this case the first method of derivation has the advantage of using only simple algebraic reductions and of furnishing very convenient upper and lower limits for the error. Thus the original process of successive divisions and taking the average may be supplemented by the above explained method of subtracting from the last average found one or more corrections. However, for general use the unsupplemented method is by far preferable as a rule easily remembered and understood, and sufficiently rapid.

The simpler rule has in addition an important theoretical significance, for it gives a very simple and satisfactory definition of the square root of any positive number. Thus if N is any positive number we may define $\sqrt{N}$ in the following way: Divide N by any convenient positive number d and denote the quotient by q and the average of q and d by a_1. Now divide N by a_1 and find the corresponding quotient q_1 and average a_2. Proceeding in this way we find two endless sequences of numbers:

$$\begin{array}{ll} \text{(A)} & a_1, a_2, a_3, a_4, \ \ldots \ a_i, a_{i+1}, \ \ldots \\ \text{(B)} & q_1, q_2, q_3, q_4, \ \ldots \ q_i, q_{i+1}, \ \ldots \end{array} \quad \text{where} \left\{ a_{i+1} = \frac{a_i + q_i}{2} \right.$$

$$a_i q_i = n.$$

such that the sequence A decreases while the sequence B increases, and the difference between a corresponding pair of terms of A and B, $a_i - q_i$, is positive and approaches zero as i increases. Also the square of any term in A is greater than N, while the square of any term in B is less than N. The sequences A and B approach therefore the same limit and this limit is $\sqrt{N}$.

These facts may be proved without assuming the existence of $\sqrt{N}$, as is desirable in such a definition. The proofs are not difficult and are left to the reader as an exercise. A similar definition may be formulated for any root of a positive number.

TWO METHODS OF LOCATING THE GERMAN SUPER GUN.

By Harris F. Mac Neish,
College of the City of New York.

Method by Means of Circles.

Three observation stations, A, B, and C, are established near the front line, Station A being somewhat in advance of B and C. Station A is connected by wire with Stations B and C, and an instrument is set up at A so that the pushing of a button will start clocks going at B and C. When the discharge of the gun is heard at A the button is pushed, and when the discharge is heard at B and C the time is recorded by the observers.

Suppose the time recorded at B is two seconds, and at C three seconds. The velocity of sound is accurately determined in advance, but for simplicity assume the velocity to be 1,000 feet per second. It is evident then that A is 2,000 feet nearer to the gun than B, and 3,000 feet nearer than C.

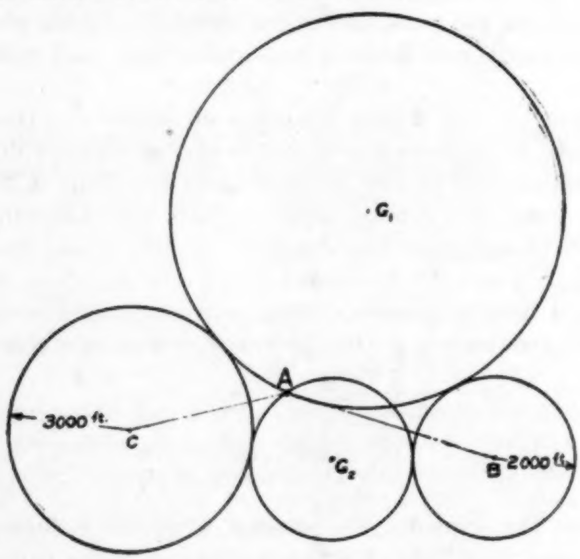


Figure 1

A, B, and C are located accurately on a military map (see Figure 1), and two circles are drawn on the map to scale, one with B as center and 2,000 feet as radius, and the other with C as center and 3,000 feet as radius. Two circles are then drawn passing through A and tangent externally to the circles about B and C. Call the centers of these circles G_1 and G_2. G_1 and G_2 are evidently 2,000 feet farther from B than from A, and 3,000

feet farther from C than from A, and hence one of them is the required position of the gun. In practice one of the two positions, G_1 or G_2, may be excluded by direct observation as one of the two points usually lies back of the lines. Moreover, the determination is repeated many times, based upon successive discharges of the gun, and upon different positions of the stations, and the vicinity of the gun is located accurately within certain limits.

Method by Means of Hyperbolas.

Three stations, A, B, and C, are established as before. The stations are provided with very accurate clocks which are set at exactly the same time (clocks are available measuring time accurately to one one-hundredth of a second). When the discharge of the gun is heard, the time is recorded at the three stations. Suppose that as before the velocity of sound is taken as

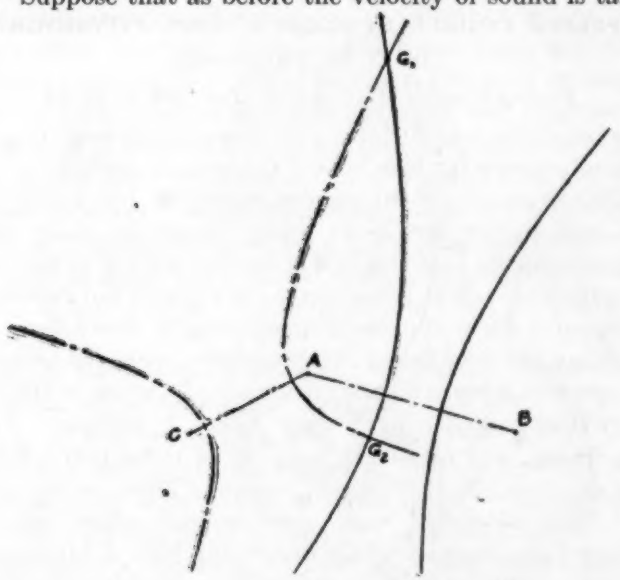


Figure 2.

1,000 feet per second and that the gun is heard at A two seconds sooner than at B and three seconds sooner than at C.

The gun is therefore 2,000 feet nearer to A than to B. The locus of all points, the difference of whose distances from A and B is 2,000 feet, is a hyperbola drawn with A and B as foci and 2,000 feet as transverse axis. The branch adjacent to A is the locus of all the points 2,000 feet nearer to A than to B.

A, B, and C are located accurately on a military map (see

Figure 2), and the branch of the hyperbola drawn on the map to scale. The gun is situated somewhere in this curve. Similarly, a hyperbola is drawn with A and C as foci, and 3,000 feet as transverse axis. The gun will also be situated on the branch of that hyperbola adjacent to A. These two curves will intersect in two points, one of which will be the required position of the gun. In general, as before, no difficulty would be encountered in determining which of the two positions is the correct one. However, a third hyperbola may be drawn from the data with B and C as foci and 1,000 feet as transverse axis, and the gun will lie on the branch adjacent to B.

This branch will in general pass through only one of the two points previously determined, and the position of the gun will be determined uniquely.

AN APPLIED COURSE IN HIGH SCHOOL PHYSIOGRAPHY.

By O. W. Freeman,

Fergus County High School, Lewistown, Mont.

It is becoming a habit for science teachers to urge the merits of general science for high school students in preference to any particular science. Physiography especially has suffered as a result, and the subject is no longer taught in many schools. The writer admits that general science has a place in the curriculum and teaches a first-year class in the subject, but believes that physiography offers a splendid opportunity to direct the students along many practical lines. Physiography is elected by seventy-three per cent more students than general science in the Fergus County High School at Lewistown, Mont. It is popular with the upper classes, and fifty-eight per cent of those taking physiography are from the three upper classes. Thirty-seven per cent of the class have had some other science course previously. Lewistown is in an exceedingly interesting part of Montana from a geologic, physiographic, and mining standpoint, and the subject of physiography fills a real need in an institution located there. The writer has adopted the suggestions of others along with his own for an applied course in physiography, and the course as given is the result of many years of teaching the subject and is modified from year to year.

The school year at the Fergus County High School is thirty-eight weeks long, of which two weeks are used for examinations. A textbook is followed so far as general topics are concerned, but recitations on the assignments are the least part of the course.

Lectures by the instructor are not overemphasized and are usually limited to giving examples of the topics under discussion from Montana and Fergus County in particular. No textbook in physiography can hope to be complete for any particular locality. To make a course practical or interesting it must be supplemented by local examples. A large number of lantern slides, especially on local subjects, are used for illustrative purposes. The lantern is a Baush and Lomb with reflectoscope attachment, and picture post cards and illustrations from books, magazines, etc., are freely used. Frequent reference is made to the daily press and current magazines for such topics as: Influence of weather on the war, the reasons for the success or failure of fruit and grain crops in Montana and elsewhere, and the reasons for the location of cities and new manufacturing plants. Considerable commercial geography can be thus taught, and if an illustration is timely it is used without waiting until the most closely related part of the text is reached. Constant use is made of both physical and political maps and they are particularly used to show the cause for the varying climates of the earth and the effect of climate and topography on the distribution of population and the character of man's activities, industries, and culture. It has been found that the average high school pupil is weak on locational geography and it is necessary to locate on the map many places with which a student should be familiar.

Instead of the instructor giving all the outside information to the students it has been found that they will listen better and remember more if one of their own number looks up the matter and makes a report to the class upon it. These reports are also desirable as they help the student gain in power of expression. Usually only certain parts or chapters of a book are used as a basis for reports. Among the books found useful are the following:

Bowman, *Forest Physiography;* Russell, *Lakes of North America; Rivers of North America;* and *Glaciers of North America;* Salisbury, Barrows, and Tower, *Modern Geography;* Brigham, *Geographic Influences in American History;* Mill, *International Geography*; Davis, *Geographic Essays*; Geike, *Earth Sculpture;* Bonney, *Volcanoes;* Davis, *Meteorology*; Ward, *Climate;* Merrill, *Rocks, Rock Weathering, and Soils;* Pirsson, *Rocks and Rock Minerals;* Wallace, *Island Life;* Fairbanks, *Physiography;* Salisbury, *Physiography;* and many others. Many of the publications of the U. S. Geological Survey, Weather Bureau, Smithsonian Institution, Carnegie Institution, Forest Service, Department of Agriculture, Department of the Interior, and various state departments have been used. Many technical and popular magazines have also been used.

Laboratory work and field trips take up two days out of five

each week. No laboratory manual is used, but notebooks are kept. Some fifty different contour maps are studied in considerable detail. Montana maps are emphasized, but typical examples are chosen from all parts of the United States. Special attention is paid to the effect on man of the cycle of erosion in both an arid climate and a humid climate. In order to make the maps seem more real to the students, each is frequently asked to describe from a study of the map what would be seen by looking in a certain direction from a given hill or other landmark, and what would be the origin of the land forms seen. No useless cross-section work on topographic maps is done. Series of weather maps are studied until the influence of cyclonic and anticyclonic areas on the weather are thoroughly understood. Some models are available but are used only for demonstration. More time is spent in a study of rocks and minerals in this western community than would probably be wise in many parts of the East and Central West. The rocks are studied mainly in the field and include limestone, sandstone, shale, conglomerate, coal, gypsum, quartzite, granite, diorite, lava, volcanic tuff, and various porphyries. The minerals studied are all in Montana and most of them are in Fergus County and include: calcite, dolomite, calcareous tufa, halite, and other alkaline salts, quartz, gypsum, hematite, magnetite, limonite, pyrite, gold, galena, calaverite, argentite, spalerite, various feldspars, horblende, augite, covellite, chalcocite, bornite, chalcopyrite, azurite, malachite, sapphire, topaz, garnet, and some others. A few fossils are studied, mostly on field trips, but a considerable number are available for inspection in the museum.

The field trips are very popular with both the pupils and the instructor, and are taken nearly every week during the good weather of the autumn and spring. Short trips are taken during the regular class hour to little creeks and rock outcrops within a mile of the schoolhouse to study weathering and the origin of soils and maintenance of soil fertility, and the work of ground water, running water, and the wind. Several automobiles are donated by members of the class for use on longer trips, which enables the class to reach the nearest mountains in half an hour. The details of glacial phenomena so common in the lake states cannot be seen, as mountain glaciers and the continental ice sheet were not found near Lewistown. The subjects studied on the trips to the mountains include: igneous phenomena as dikes, laccoliths, sills, and dissected volcanoes, and erosional forms as

box canyons, buttes, pinnacles, rock terraces, river terraces, hogbacks, waterfalls, natural bridges, arches, caves, and sinks. Structural features like anticlines, synclines, and faults can be easily seen. Gold, sapphire, coal, and gypsum mines are visited and the general methods of mineral extraction noted. Landslides, ice caves, giant springs, mineral springs, and their mineral deposits of iron and travertine have been visited and studied on the trips. On the same trip the boys have been chilled in exploring the depths of an ice-filled cave and a few minutes later warmed themselves by swimming in a giant warm spring. The class secures an appreciation of landscape and scenic features through the field trips which can never be secured in the classroom.

The field trips are made the basis of essays on the subjects studied, and if the written work is properly done theme credit in English can be secured. The essays are read in class and freely criticized, both as to the completeness and accuracy of the information and its expression in correct language. Usually we find that a combination of parts from different essays would make a better piece of work.

The writer has no apology for introducing geology, mineralogy, and geography into a course in physiography. The subjects introduced are decidedly practical and are of use to the pupil in after life and to the students who later take agriculture, physics, chemistry, history, and other subjects. The writer prefers to use a standard introductory textbook of physiography which gives the proper background, and finds it easy to introduce the applied phases of geography in the ways suggested in this paper rather than use a textbook that pretends to introduce these things in its subject matter. Such a textbook would be of unwieldly length if it actually did introduce all these applied phases and would be suitable for use in only one part of the United States then. Each region has its own problems, and the properly trained teacher can better supplement the text than to depend on an ideal text that has not been written.

THE PENOBSCOT A BRAIDED STREAM.

The Passadumkeag, Maine, typographic map just issued by the Geological Survey, Department of the Interior, shows that the Penobscot River between Old Town and West Enfield, Maine, is a striking example of a braided stream. The river here has but slight fall and therefore cannot carry away all the sediment that is swept into it by its numerous tributaries, and this material chokes the stream and forces it to spread into many shallow and shifting channels, the pattern formed resembling the strands of a braid.

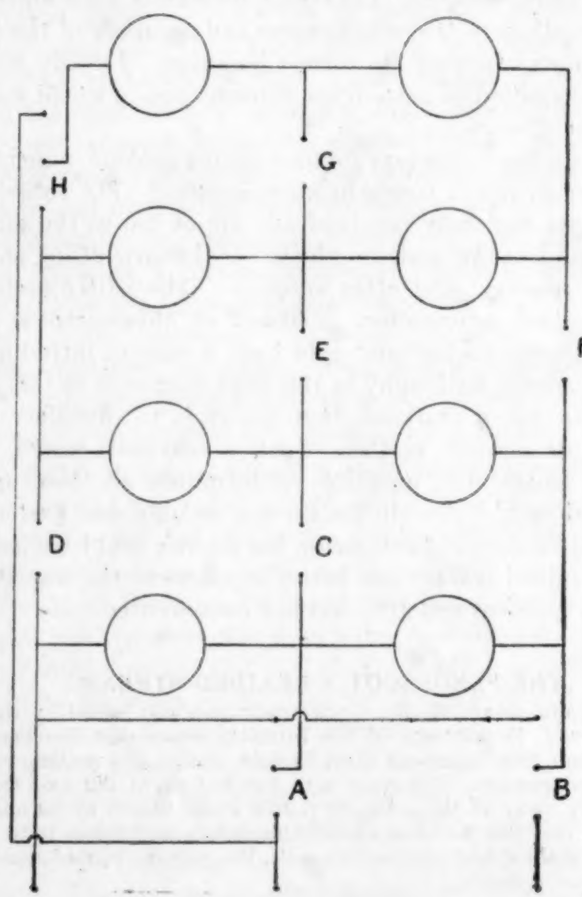
A CONVENIENT LAMP BANK.

By P. C. Hyde,

Newark Academy, Newark, N. J.

The lamp bank, of which a diagram is here shown, was devised to combine as many utilities as possible in a single piece of apparatus that should be at once simple and safe. It is used as a demonstration and laboratory piece, and as a lamp rheostat.

As appears from the diagram, there are eight lamps and eight switches, all of the latter single pole, three double throw and five single. The board is wired in front, and built large enough so that the lamps do not hide the wiring when the apparatus is hung against the wall of the lecture room. The position of the switches, open ones showing white on a white background, makes it easy for pupils to trace the path of the current at each



stage of a demonstration or experiment. For added distinctness the copper switch blades are painted black to correspond with the wiring.

The binding posts are connected to a three-wire current supply, direct or alternating. For lamps in parallel A is down (towards the binding post), H likewise, B is up, and the other switches are closed. Single lamps are extinguished by opening in succession H, G, F, E, D, C, and B. With A, B, and H all down and the other switches all closed, the lamps are connected on the three-wire system; the effect of blowing a neutral fuse, and the necessity of the neutral wire to keep the voltage even when the sides are unbalanced, is shown by opening A, which puts the lamps in multiple on 220 volts. By connecting an ammeter, preferably zero centered or alternating current, in the neutral line, the value of the current in the middle wire for unbalanced three-wire operation is clearly shown. With an ammeter in each line, the neutral current is shown to be the difference of the other two, a fact essential to the economy of the system.

With H up and the other switches open the lamps are in series, and individual lamps are cut out by closing in succession A, B, (both up), C, D, E, F, and G. The increasing current can be shown clearly by the changing glow of a 15-watt tungsten lamp adjacent to H if the other lamps are 16 c.p. carbons, as the total resistance of the latter is not sufficient to dim entirely the small lamp.

A careful examination of the diagram will show that no possible combination of switches will short-circuit either line. The only combination to be avoided is A up and B down, as this throws 220 volts across a single lamp or row of lamps. With C open and an old lamp adjacent to B it is not a bad plan to try this combination before a class, to show the need of care in testing out live wires with an incandescent lamp where there are voltages above 125, and the danger of operating unbalanced circuits in multiple.

The bank is neither difficult nor expensive to construct. The switches are of the ordinary 125 volt 15 ampere baby knife type, and the binding posts should have composition caps for protection against shock. The wiring is 14 double braid. The apparatus has proved itself decidedly convenient and instructive, and fool-proof when operated by students on a 110-volt line. Its versatility can be fully appreciated only after considerable use.

THE RELATION OF RÖMER AND FAHRENHEIT TO THE THERMOMETER.

TRANSLATED BY WILLARD J. FISHER,

Worcester, Mass.

(Ole, or Olaf, or Olaus, Römer was born at Aarhus, Denmark, September 25, 1644; died at Copenhagen, September 19, 1710. In 1662, he became pupil and amanuensis of E. Bartholin, in Copenhagen, who employed him in classifying the manuscripts of Tycho Brahe. In 1671, he helped J. Picard redetermine the geographical position of Tycho's observatory, Uraniborg. In 1671 or 1672, he went with Picard to Paris; there he became mathematical tutor of the Dauphin and member of the Academy of Sciences, and was occupied with observations in the royal observatory and the king's hydraulic works at Versailles and Marly. In 1674, probably before Desargues and La Hire, he invented the epicycloid and indicated its applications to gear teeth. September 22, 1675, he read his paper on the velocity of light as deduced from observations of the eclipses of Jupiter's first satellite. About the same time he was interested in the design and construction of planetaria. In 1681, he returned to Copenhagen, as royal mathematician and professor of astronomy in the university. He also became mayor, chief of police and privy councilor. On his advice, Denmark adopted the Gregorian calendar.

He invented the transit and prime vertical instruments and the meridian circle, and used altazimuth circles and the equatorial mounting for telescopes. His realization of the importance of clock rate in meridian work led to an interest in expansion and contraction and a fundamental improvement in thermometers, as shown below. His observations and papers perished in the Copenhagen fire of 1728, with the exception of three night's work, preserved by Horrebow, 1735, and discussed by Galle, 1845, the *Adversaria*, mentioned below, and, of course, a few published in the proceedings of the Berlin and Paris academies. At the time of his death he was engaged in attempts to discover stellar parallax, which would inevitably have led him to the discovery of aberration, for reduction of his work has shown it to be of almost modern precision.

Accessible works are, R. Grant, *Hist. of Phys. Astr.*, p. 461; Doberck, *Nature*, 17, p. 105, 1877-78; See, *Pop. Astron.*, No. 105, May, 1903. A portrait of Römer is to be found in LaCour and Appel, Vol. I.

I find slight discrepancies among the various reference works as to dates and facts of Römer's life; Doberck's article is very full.

Kirstine Meyer, née Bjerrum, has written in Danish a book on *The Development of the Temperature Concept in the Course of the Ages*, published, 1913, in the series, *Die Wissenschaft.* Her account of Römer's part in the development of the thermometer is here translated from this German edition. It appeared first in *Archiv für die Geschichte der Naturwissenschaften und der Technik*, 2, p. 323-349, 1910.—W. J. F.)

From occasional expressions in the scientific literature of the eighteenth century, on which I came accidentally, I inferred that probably Ole Römer had busied himself with the construction of thermometers, and that there had been a relation between him and Fahrenheit. I will later come back to these expressions. They led me to search in the libraries and archives at Copenhagen for works by Römer, and only at last in the University Library; for I had to assume that the papers of Römer in possession of this library had been destroyed by the conflagration of 1728. Yet there I found what I sought, namely, Römer's *Adversaria*, in manuscript, in a volume of miscellanies.[1]

A note on the last page tells how the book came into the possession of the library, and that it escaped the fire through being then in the possession of Römer's widow, remarried to Th. Bartholin. She gave it to the library in 1739. This note says:

"Da mein erster Gatte Olaus Römer Sel. diese cahiers in Pergament hat heften lassen, möchte ich annehmen, dass er sie selbst als von einiger Importance erachtete, weshalb ich dieses Volumen in der Bibliotheca Academica geborgen wissen möchte-unter anderen Manuscripten, damit jemand darin, wie zu vermuten, etwas Nützliches darin finden könnte. E. M. Bartholin, Witwe von Th. Bartholin Sel., in octobre 1739."

This book contains a whole section on the thermometer and, besides, a few isolated remarks on temperature measurement. Römer's form of the thermometer seems to me to be of great interest; he is apparently the first to construct the thermometer with two fixed points, namely, the temperatures of melting snow (nix sine gelu et calore) and the boiling point of water, and with a division of the tube into equal volumes.[2] This happened in 1702, partly according to Römer's own notes, partly according to Horrebow's. In *Adversaria*, p. 131 b., there is a reference to Amonton's comparison[3] between his own and Newton's[4] statements of equal temperatures; Römer makes a brief extract from the comparison tables, and adds:

"The observation of the incipient freezing and of the boiling of water seems to me in the highest degree adapted for application in the construction and graduation of a universal thermometer, as the former point is sufficiently well fixed, and the latter, contrary to my earlier view, deserves confidence; for, according to the concurrent observations and reliable assurances of the French, boiling water, once the boiling has begun, cannot increase its temperature."

In 1703, then, Römer seems to have been clear about the principle. Horrebow has made marginal notes at various places in the *Adversaria*, from which it appears that Römer made his thermometers about 1702. He writes,[5]

[1]This *Adversaria*, written mostly in Latin, has been published by the Royal Danish Scientific Society on the occasion of the two-hundredth anniversary of Romer's death, under the editorship of cand. mag. Thyra Eibe and Dr. phil. Kirstine Meyer.

[2]On this see translator's note at end.

[3]Mem. de l'Academie Roy. des Sciences, 1703, p. 100.

[4]Roy. Soc. Phil. Trans., 22, p. 824, 1700-1701. On this scale the ice point is zero, body heat 12, water boiling violently 34; this makes body heat 35.3 C.; cf. 36.9, actual mean. I do not know that Newton ever attempted to construct a thermometer giving these readings, and I think the original shows that he did not consider the boiling point of water a constant, in spite of the observations of Halley and others.—W. J. F.

[5]*Adversaria*, p. 118 b.

"1741, on April 10, I asked Römer's widow when he had made the five thermometers.[6] She answered, they had been made in her presence; she could not, however, recollect any contemporaneous event, through which the date could be determined; but at that time Römer could not get out, owing to a broken leg. Consequently it was before 1703, the year in which, in June, I came to Römer's observatory, for Rumohr, John and other assistants were telling that he had been dangerously ill with wound fever after a broken leg.

"On 17 April, Römer's widow came to me and said, now she knew certainly that these thermometers had been made in 1702."

The section of the *Adversaria* which deals with thermometers, etc., consists of eleven folio pages. The first heading runs, "On the calibration of glass tubes for thermometers." A solution is given of the problem, so to divide thermometers with various sized bulbs and bores, that the divisions shall agree; i. e., so that the volume of ten divisions shall everywhere have the same ratio to the volume of the bulb. He finds the diameter of the tube by means of a quicksilver drop; this he puts into the tube and measures its length, then he weighs it and calculates its volume, assuming that a cubic foot of quicksilver weighs 837 pounds. From this we see that he takes the specific gravity of quicksilver 13.5, as in the system of measures used by him a cubic foot of water weighs 62 pounds.

After he has determined the length and volume of the drop, he calculates its diameter, and so the diameter of the tube, at the region where the drop lies. That Römer is interested in this connection with the problem probably depends on this: that on several sides, as, e. g., by R. Hooke, it had been proposed to make mutually agreeing thermometers on the following principle: one fixed point, and a division of the tube into equal volumes, which should in all thermometers be in the same ratio to the bulb volume.

After solving this problem he gives a suitable formula, and adds that this really has nothing to do with his investigations, which were for determining the irregularities of the tube bores, usually conical or of irregular form.

"I investigate their form by means of a quicksilver drop before the bulb is blown on. In the tube previously mentioned I have found a sufficiently regular part, so that at the middle a

[6] It had previously been mentioned that Hörrebow had used these.

drop of quicksilver had length 7 1-2, at the wide end 8, at the narrow end 7 (arbitrary units). Between these points there were ten inches. We can consider this space a truncated cone. In this, unequal thermometer graduations must be made; i. e., longer toward the narrow end, shorter toward the wider cross-section."

The following pages deal generally with the division of conical spaces into equal volumes. Römer develops for this the necessary formulas, and explains them with numerical examples. So he finds a method suitable for dividing a conical tube into equal volumes. Then he passes to his principal problem, for whose sake the preceding developments were entered on, "To construct an original (standard) thermometer."

1. With a quicksilver drop it is found whether the tube is of regular internal form, cylindrical or conical, and, indeed, before the bulb is blown on. Irregular forms are thrown away, cylindrical are used without more ado. With conical ones we have to deal thus:

2. From the middle toward the ends we determine the lengths of quicksilver drops.

3. When the tube is thus divided into two equal parts, then each of these is again divided into two equal parts, so that we now have four equal parts.

4. When the thermometer is completed, filled and sealed, we fix with snow or pounded ice the point 7 1-2, and by boiling, the point 60.

After this are notes, written and signed by Horrebow:

"The distance from the limit of the snow to boiling (melting point to boiling point) Römer divides into seven equal parts, of which the one below the snow limit serves him for observations of greater cold. When he afterward noted that the thermometer sank below zero, he began to number downwards, from zero on with the sign −.

"1739, Römer's widow sent me five glasses for thermometers, which Römer himself had filled according to his rules described above, and had marked with two points. The spirits of wine in them is pretty pale, although Römer had colored it in the usual way. I asked Römer's widow if she knew whether Römer, after I left his observatories, had made any changes in his thermometer. She said that she did not know, but gave me Römer's 'Vade Mecum', in which I found a loose leaf, that is here pasted in after the next leaf. On this sheet I see that Römer had put in the graduation mark for snow; now, insofar as we know, the spirits of wine never sink below zero in Copenhagen, and it is noted that on 7 January, 1709, the spirits sank only to 7 9-10."

This loose sheet mentioned by Horrebow contains a table for

the daily temperatures from 26 December, 1708, to 1 April, 1709.[7]

(Here follow a description and a partial figure of Römer's graphical record of temperature, one of the earliest temperature records which can be translated into modern scales with approximate accuracy. For these I make reference to the original. —W. J. F.)

Certain places in the *Adversaria* lead one to suspect that Römer had considered dividing the tube into equal lengths and making for each thermometer a table of the deviations shown between the readings of such a thermometer and one divided in equal volumes.

To sum up: We arrive at the conclusion mentioned above, the thermometer graduation rests on two fixed points, the melting point of snow, usually called the "freezing point," and the boiling point of water, and then on the determination of degree lengths by division of the tube between the two fixed points into equal volumes, in doing which account is taken of the cylindrical or other form of the tube. The size of a degree is such that between freezing and boiling points there are 52 1-2 degrees of equal volume. If the tube is cylindrical, this distance is divided into 52 1-2 equal lengths, and 7 1-2 such are marked off below the freezing point, giving the zero point; if the tube is not cylindrical, but conical, the graduation from freezing point to boiling point is carried out according to Römer's previously given method for the graduation of conical tubes; the zero point is so located that the volume from zero to freezing point is 1-7 of that from freezing point to boiling point.

Römer's thermometers were still in existence up to 1748,[8] for in his *Elementa Philosophiae Naturalis*, p. 144, Horrebow says that he had got from Römer's widow, who still owned them, five thermometers. In the *Adversaria* Horrebow tells further that he had tested them, and remarks,

"At the beginning of April, 1741, I separated from their scales five Römer thermometers, and tested them in snow and boiling

[7]This winter is famous on account of its severity. According to Romer, uninterrupted frost reigned during the period covered. But in spite of the lowest temperature, which happened twice, being only 0^0 (Romer) = —14.3^0 C., the winter got its reputation for severity through the long duration of the frost. In the *Theatrum Daniae* of Pontoppidan, he says of the winter of 1709, "It was in these and neighboring countries an extraordinarily hard winter. In the woods much game froze to death and many trees died; indeed, we heard of many travelers who froze on the way. On the Baltic (Ostsee) even in the month of May sleds traveled as on highways."

[8]*Nordisk Universitets Tidskrift*, 1859, p. 3, contains an essay on Romer by E. Phillipsen; in a note, p. 52, it is said: "Of his various instruments and machines there exist now, beside the remains of a barometer and a thermometer of his own make, which belong to the collection preserved in the former Art Museum . . . . . ." The objects mentioned I have not found listed in the catalog of 1848. Neither in Schloss Rosenborg, nor in the National Museum, whither the objects of the Art Museum were taken, was there any trace of them to be found.

water, and found after so many years exactly the same readings that Römer himself had marked with a flint."

When one sees that Römer had spent comparatively much of his closely occupied time in the construction of an "original" thermometer, there suggest themselves three questions: (1) Is this interest connected with Römer's other scientific and practical labors? (2) Did he use the thermometers so constructed for systematic measurements? (3) Did his new ideas influence others in the construction of thermometers? I will attempt an answer to these questions.

From the *Adversaria* we can conclude that the first question is to be answered, *Yes.* For two reasons: Römer wished to determine the expansion of metals by heat, partly to determine the variations with temperature of the size of a degree in an instrument in his "Observatorium Domesticum," partly to determine the temperature variation in the periodic time of a pendulum. The latter may have interested him partly on account of his astronomical observations, partly on account of his endeavors to found a system of units. Without doubt, he, in common with Picard, was planning for the introduction of a *normal foot,* in order to express in terms of it the customary length-units of different countries, and for that purpose he wished to make use of the length of the seconds pendulum. Römer and Picard assumed that this was the same everywhere on the earth.[9] Measurements by Picard, in Paris, and, with Römer's help, at Uraniborg, and by Römer himself at London, had in fact given the same value.

According to p. 67 of the *Adversaria* Römer had occupied himself with the expansion of various metals. It reads:

"Changes in length of metals by cold and heat, tried 12 December, 1692, three or four times."

Römer's measurements—whose method he unfortunately does not describe—showed that the lengths of three-foot rods of various metals, which he had divided into 6,800 equal parts, increased differently for equal warming. If his thermometer read 6 1-2 in the cold and 30 1-2 when heated, or rose 24, then the 6,800 parts increased:

For gold and copper	5 parts
For silver and tin	6 1-2 parts
For lead	9 1-2 parts
For iron (at most)	3 1-2 parts
For glass, a round tube of 1-2 inch diameter	3 1-2 parts

[9]I find this hard to understand, as Romer, 1672-3, was one of the observers who worked at Paris simultaneously with Richer at Cayenne for determining the solar parallax by observations on Mars, etc.; he could, therefore, hardly have been ignorant of the way Richer's clock varied with the latitude, when the clock was set up at Paris and at Cayenne, nor of the controversy that ensued.—W. J. F.

so that a fiber of lead increased about 1-10 inch, of gold or copper about 1-2 inch, of tin or silver 1-15 inch, of iron and glass 1-3 inch.

"Now my instrumentum domesticum[10] can easily be kept between the cold 6 and the warmth 16, which consequently corresponds to a difference of at most eight parts on the thermometer; or, better, between eight graduations, which is a third of that observed.

"Later I added this; a higher temperature can be avoided; but cold can depress the fluid to graduation 4 near the window, where the instrument is, as I have just observed. A difference in cold and warmth of 11 and 12 is therefore to be expected; i. e., half as much as I observed in case of the rods."

The instrument here mentioned, Römer's famous meridian instrument, is figured in Horrebow's *Basis Astronomiae*. In the picture we see beside the telescope of the meridian instrument a clock, serving for the necessary determination of time. Probably Römer calculated the changes in rate of this instrument due to temperature changes. The fact is, that the iron pendulum rod altered in length 1-100 line for each thermometer degree, but a change in length of 1 line increases or decreases the rate 1 second in 24 hours.

Further, an apparatus is sketched[11] for making comparative measurements of the expansion of air and liquids by heat. It consists of a glass bulb, 1 1-2 inches in diameter, with a narrow neck, of which a length 16 1-3 inches is equal in volume to 1-22 of the bulb. Were the tube filled with water at 8° to *a*, then on heating 10° the water expanded to *b*, a point 1 3-4 inches distant from *a*, so that the expansion amounted to 1-200 of the original volume; were the bulb filled with air, inclosed by a drop at *a*, the air expanded on heating 3° to *c*, 12 inches from *a*, and on heating 10°, and with a sufficiently long tube, would have expanded 40 inches along the tube, or 1-9 of the original volume.

The increase in volume of air on 10° heating is consequently 22 times as great as that of water. Römer adds, that he had previously got the number 24; however, the later experiments were better. According as we assume that the 8° of Römer correspond to 0° C. or 15° C., we get a poor or a good agreement with modern measurements.

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[10]The "Observatorium Domesticum" was founded 1689-90. It is described in Horrebow's *Operum mathematico-physicorum*, Tom. III, p. 47. (Figures of Romer's instrumentum domesticum, etc., are found in H. H. Kritzinger, *Die Errungenschaften der Astronomie*, p. 69, Weimar 1912; L. Ambronn, *Handbuch der Astronomischen Instrumentenkunde*, II, p. 905-907.)

[11]*Adversaria*, p. 5.

There exists a series of measurements of the air temperature at Copenhagen in the winter of 1709, made with the new thermometers. These measurements are of especial interest, and were occasionally mentioned in foreign literature.

The winter of 1709 was very severe. In an essay entitled, "The History of the Great Frost in the Last Winter, 1708 and 1708-9,"[12] Dr. Derham writes of the conditions in Denmark. From his discussions we see how great was the progress of Römer, and how far his fundamental idea lay from that of his time, as Derham did not at all understand the principle of his thermometer graduations. Derham writes: (p. 458) "As to the Northern Parts, the before commended Dr. *Woodward* tells me, that in a letter he received from the learned Mr. *Otho Sperling*, from *Copenhagen*, dated *April 6, 1709*, he calleth it *Hymens Atrocissima.* And I find it noted in the minutes of the *Royal Society* of *May 4, 1709*, 'That Dr. *Judichar* said the ice was frozen in the harbour of *Copenhagen* 27 inches; and that *April 9, N. S.*, People had gone over between *Schone* and *Denmark* on the ice,' which Accounts give me a better Opinion of some Papers I have by me, which were showed to the *Society*, concerning the Frost at *Copenhagen*, pretended to be taken from the Observations of Mr. Römer. I should not entertain the least distrust of the Accuracy either of the Instruments or Observations of that eminent Person, were I sure they were his. But there were some Passages and Hints in those Papers that lessened others, as well as my Opinion about them. 'Tis said there, "That such a Frost hath not been known in the Memory of Man in these Countries, and that the Frost on *January* 7, and *February* 23, 1708-9, did very nearly approach the Point of Artificial Freezing."

If we examine the tables of Römer's temperature observations in 1708-9, in the *Adversaria*, it appears that it begins 26 December, 1708, and continues to 9 April, 1709; although from 1 April, 1709, on, observations are not entered for every day,

[12]Dr. W. Derham was a clergyman of the Anglican Church at Upminster, and a frequent contributor to the Royal Society, on meteorological and other subjects. The following quotation is pertinent, though not given by K. Meyer:

W. Derham, *Roy. Soc. Phil. Trans.*, 26, p. 335, 1709.

Speaking of a comparison of his own thermometer observations at Upminster with those of Dr. Joh. Ja. Scheuchzer, in Zurich, he says: "I. For the *Thermometer*: It would have been in vain to have compared his Observations with mine, by reason we have not got a standard for Thermometers, as we have for the Barometers; they being everywhere in all, or most respects, different; some with large, some with small Bottles of Spirits; some accordingly with longer, some with shorter; some with wider, some with narrower Canes, or Shanks; some filled with more highly rectified, and consequently more expansive Spirits, some with more phlegmatic and duller Spirits.

The quotation in the text is from *Roy. Soc. Phil. Trans.* 26, p. 454, 1709.

"The History of the Great Frost in the last Winter, 1708 and 1708-9, by the Rev. Mr. W. Derham, Rector of Upminster, F. R. S.

doubtless because the table was to record only temperatures under 8°. The notes in the margin are Horrebow's; above the table there stands: "Römer consequently had changed his first proposition." That means, as Horrebow's marginal notes in the *Adversaria* show, that Römer had made the number 8 the melting point, instead of 7 1-2 as previously.

Now the table shows that exactly on 23 February, which Derham mentions specially, the thermometer sank almost to Römer's zero point. Recall the expression with which Derham refers to this fact: "that the Frost on *January* 7 and *February* 23, 1708-9, did very nearly approach the Point of Artificial Freezing." From this it follows that Römer's zero point was exactly the temperature of a freezing mixture,[13] a fact which Derham himself must have got from the information originating in Denmark, as he did not know Römer's scale. The remark has particular interest for the treatment of the question, whether, and if so, in what ways, Römer's thermometer became important to wider circles. The answer is, through Römer's influence on Fahrenheit.

We have direct expressions on this point, first by Boerhaave. He asserts that water can exist in the fluid state at temperatures above 32° Fahrenheit. In this connection he narrates[14] that "the distinguished mathematician Römer in the year 9 of this century observed in Danzig a winter cold (down) to the first degree of this same thermoscope, of which he was himself the inventor."

Here Römer is expressly represented as the first maker of Fahrenheit thermometers. Boerhaave's statement has double importance, as he stood in close relations with Fahrenheit, who had made him thermometers, and whose skill as instrument maker he often mentions with praise. The statement that Römer made measurements in Danzig in 1709 rests on a misunderstanding; as we shall see below, measurements were made with a similar thermometer in Danzig, not by him, but by others. At all events it cannot be shown that Römer was then abroad; his numerous official duties, his delicate health,[15] and particularly the table of temperatures at Copenhagen make this doubly improbable.

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[13]See translator's note at end.

[14]H. Boerhaave, *Elementa Chemiae, Lugduni Batavorum*, 1732, T. 1, p. 720.

[15]His death in 1710 was due to stone, from which he suffered a long time.—W. J. F.

We find also other statements that Römer was the true inventor of the Fahrenheit thermometer. These can frequently be referred back to Boerhaave. So the English physician Martine writes[16] that the quicksilver thermometers were first invented by Römer; but as he at the same time refers to the just-quoted passage in Boerhaave, we see that he confused the invention of the Fahrenheit thermometer, which was Römer's, and that of the quicksilver thermometer.

In Danzig the matter was gossip, apparently. Hanow writes in Danzig, 25 February, 1736[17] ". . . According to the most accurate weatherglasses, which Herr Römer in Danzig has designed, and which Herr Fahrenheit makes the best, water boils at 212 and freezes at 32 degrees."

In a later enlarged edition of this book by Titius, Leipzig, 1753, reference is made directly to Boerhaave, which Hanow did not. Hanow's views apparently varied. In an essay of 1745 by v. Bergen it is said of Fahrenheit, "To whom Römer, that very zealous friend of the physical and astronomical sciences, had suggested the freezing and boiling limits in the construction of thermometers, if we may believe Hanow in the *Memorabilia Gedanensia*."[18] This expression has in recent times led E. Gerland, in connection with Hanow, to assert that it was Römer who suggested to Fahrenheit the applicability of freezing point and boiling point in the temperature graduation. At the same time Gerland tries to limit this credit; among other things he says[19] that Fahrenheit's discovery of supercooling[20] taught him to use the melting point of ice, and not, as Römer had advised him, the freezing point of water. As appears from Römer's own papers, he used exactly this melting point of snow, so that it is not probable he advised Fahrenheit otherwise.

Later, Hanow gave up his above-mentioned view about Römer's influence on Fahrenheit, for in the second edition of his treatise, 1757, v. Bergen says[21]:

"In the first edition of this work I say that Fahrenheit owed the excellent idea of these fixed points (freezing point and boiling point) to the keen-minded Römer; but to assert this now I am

[16]Essays Medical and Philosophical, August, 1738; in an essay on thermometers.
[17]Erlauterte Merkwurdigkeiten der Natur, p. 62; (a sort of weekly, published by Hanow.)
[18]De thermometris mensurae constantis Commentatio Francfortii ad Viadrum 1745.
[19]E. Gerland u. F. Traumuller, Geschichte der Experimentierkunst, 1899, p. 249, p. 251.
[20]Roy. Soc. Phil. Trans., 33, p. 81, 1724-5.
[21]v. Bergen, Commentatio de Thermometris, 2. ed., Nurnberg, 1757, p. 22, note.

forbidden, by a letter which the famous Hanow has written me, in which he says, Römer's arrangement was derived from the then customary graduation of thermometers in the Académie des Sciences at Paris, introduced, if I remember correctly, by de la Hire . . . . . . I assent gladly, for I do not at all understand by what accident this important invention was reserved for Fahrenheit, a quite uneducated man; for de la Hire's thermometer is not provided with these fixed points."

We now know certainly that Hanow's account of Römer's scale is inaccurate, but even the fact that he gives it shows that he knew of the existence of a Römer thermometer, without knowing the thermometer itself. Consequently, Gerland's suspicion is untenable, that Hanow had his information from Fahrenheit; further, Gerland says of Fahrenheit, that in 1710 he came to Danzig, and in fact from Copenhagen, where he visited Römer in 1709.

Thus we come to the question, Can an influence of Römer on Fahrenheit be proved, and in what direction? In his biography of Fahrenheit Professor Momber collects[22] what is known with certainty about Fahrenheit's dwelling places at various times; he does not believe that it can be fixed, when Fahrenheit visited Römer; but that he did visit him he regards as settled. Also, the principal source of our information about Fahrenheit's youth, a manuscript in the Royal Library in Berlin, makes this probable; here it is related, that as late as 1706 Fahrenheit was making many laborious journeys on land and water, and had conferences with the famous mathematicians in Denmark and Sweden.[23]

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[22]*Schriften der Naturforschenden Gesellschaft* in Danzig, N. S. 7, p. 108, 1890.

[23]My authority here is the *Altpreussische Monatsschrift*, 1874, in which Strehlke has published a fragment of Wuttstrack's "Collectaneen" (materials collected) for his unpublished work, *Historisch-topographisch-statische Nachrichten von Danzig. Bialystok*, 1804.

In a volume of collections in the Royal Library at Berlin, there is the following account, by a foreign hand of the eighteenth century, in the chapter on famous Danzigers (Fahrenheit 1686-1736, written 1740): It is related of his childhood that he was really destined for study, and then—"But by the unexpected and sudden death of both his parents, who left this world 1701, 14 August, in their garden house, this plan was set back, since his guardians found it advisable to dedicate him to trade. To this, therefore, he was obliged to yield (though not without revolt) and (after he for some time received the necessary instruction in bookkeeping) Anno 1702, was sent to Amsterdam to learn the business with Hermann von Beuningen, now dead, where also he remained for the stipulated four years' service; but, instead of continuing in business, his so long hindered natural inclination toward studies spurred him on anew to follow his intended goal. To that end he made many laborious journeys on water and land, conferred with the most famous mathematicians in Denmark and Sweden, sent his instruments to Iceland, Lapland and other places, whence the observations made by interested people were sent to him at Amsterdam; and it is well known (wie den notorisch) that already, Anno 1709, in the severe winter he had made very noteworthy observations with his weatherglasses, of which mention was made in various news items on the occasion of the severe cold occurring in this 1740th year. Ao. 1710, after the end of the pest, he visited his blood friends in Dantsig 1711, he went to Kurland and Liffland, whence, 1712, he returned and cultivated intimate relations with the then living Professor Math. Paul Pater. Ao. 1714, he traveled to Berlin and Dresden, in order to superintend in person the manufacture of the tubes for his instruments in the glass works there, from whence later to Amsterdam, where afterwards he lived continuously." (Beside these journeys, Fahrenheit lived in England at dates not recorded in the reference books which I have examined.—W. J. F.)

On this Momber says, "These statements seem to me to be especially reliable, since in the first place, as far as they can be checked by source documents, they are found to be true, and, further, written down four years after Fahrenheit's death, their whole character points toward an author who stood in very close relations with him and his family." Professor Momber was so friendly as to communicate to me that he has later found nothing giving definite information about the relations between Fahrenheit and Römer.

From the manuscripts mentioned it is clear that between 1702 and 1710 Fahrenheit was in Denmark and in relations with Römer, that is, exactly at the time when Römer was working on his new thermometers. In Titius' *Oddities of Nature* it is several times mentioned that, 1709, measurements of temperature were made "with the weatherglass of Fahrenheit, famous in Danzig on account of its accuracy, and in use as early as 1709."[24] Further, he says of this weatherglass, "Wilki's weatherglass, which Krikart owned and described in the year 1709, also agrees. Since this Krikart is said to have owned such a glass as much as twenty years before 1709, but not to have described it before 1708, it seems to have been filled at the beginning of the frost in the year 1708 with fresh spirits by Fahrenheit, and to have been arranged according to his method."[25]

Consequently, it is probable that Fahrenheit met Römer, and, if Boerhaave's statement is correct, in the oldest Fahrenheit thermometers we must trace Römer's influence.

From Römer Fahrenheit could learn the following: the principle of two fixed points as basis of the scale, and the graduation in equal volumes. Fahrenheit has described the construction of his thermometers only briefly[26];—

". . . . . . Two sorts of thermometers are principally made by me, one filled with spirits of wine, the other with quicksilver. Their length varies according to the use they are to serve. They are all alike in this, that the degrees of their scales agree among themselves, and that their variations occur between fixed limits. The scales of thermometers which are intended mainly for meteorological observations begin below at zero and end at the 96th degree. The division of this scale rests on three

[24]Titius, *Seltenheitenheiten der Natur*, p. 666.
[25]l. c., p. 693.
[26]*Roy. Soc. Phil. Trans.*, 33, p. 78, 1724. (This is in Latin: I have translated directly, and somewhat more at length than K. Meyer, rather than retranslate from the German.—W. J. F.)

fixed limits, which are determined in the following manner: the first of them is found at the bottom or beginning of the scale, and is got with a mixture of ice, water and sal ammoniac or sea salt; if the thermometer is placed in this, the fluid descends to that degree which is marked zero. This experiment succeeds better in winter than in summer. A second boundary is obtained, if water and ice are mixed without the above-mentioned salts. The thermometer being placed in this mixture, the fluid reaches the thirty-second degree, called by me the boundary of freezing, for stagnant water is covered with very thin ice when in winter the fluid of the thermometer reaches this degree. The third boundary is found at the ninety-sixth degree; the spirit expands just to this degree when it is held in the mouth or armpit of a living man in good health so as to acquire perfectly the heat of the body. But if the heat of a man in fever or subject to some other fervent disease is to be tested, another thermometer is used, whose scale is prolonged to 128 or 132 degrees. Whether these degrees are sufficient for the heat of every fervent fever I have not yet found out; though it is hardly to be believed that the fervor of any fever would exceed these degrees. The scale of thermometers with which the degree of heat of boiling liquids is to be tested also begins at zero and contains 600 degrees, for about this degree the mercury (with which the thermometer is filled) itself begins to boil . . . . ."

Here then Fahrenheit tells that the goodness of his thermometers depends on the use of fixed points, between which the graduation is carried out. Of the here mentioned three fixed points only one apparently—the freezing point—corresponds to those used by Römer. From the assertions of Derham, quoted above, it appears that Römer's zero of 1709 was put equal to the temperature of a freezing mixture[27], and the fact that the quicksilver in the severest winter within human memory approached this point had certainly given it a special importance, so that it is not unlikely that Fahrenheit—and perhaps Römer also—chose this limit as a fixed point for such thermometers as were not to indicate temperatures to the boiling point of water. As we shall see in the various scales of 1708 to 1714, which bear Fahrenheit's name, this fixed point was not quite definitely determined; from the words quoted above, "This experiment succeeds better in winter than in summer," we can see that Fahrenheit does not think that he always gets exactly the same temperature. The

[27] See translator's note at end.

third point is perhaps then introduced as a sort of check. In the earlier years Fahrenheit kept his construction secret and surprised his contemporaries in the highest degree by the agreement among his thermometers.

Fahrenheit's oldest thermometers are mentioned in various places. Grischow[28], especially, gives a detailed collation of the various scales according to which they were graduated. The later discussions, of which Van Swinden's *Dissertation sur les Thermométres,* Amsterdam, 1778, is very complete, are mainly based on Grischow. According to Grischow[29] and others,[30] Fahrenheit is said to have communicated the secret of his thermometer graduation to his instructor (Repetitor) in mathematics, Barnsdorf, of Rostock; and of it he asserted that anyone, knowing it, could make agreeing thermometers. Grischow writes that this happened about 1712 or 1713, if not earlier. Shortly thereafter Fahrenheit went to Halle and Leipzig; and Barnsdorf, in company with his colleague Lange, tried to make thermometers according to his directions. The scale of these thermometers was somewhat different from that of those which later passed under Fahrenheit's name, and it is said of Barnsdorf that he certainly "had kept Fahrenheit's older or oldest graduation." From a table it is clear that Barnsdorf's thermometers showed 7 1-2 at the freezing point and 22 1-2 at body heat; these degrees are subdivided into smaller, in fact into eight, degrees each. The use of 7 1-2 at the freezing point indicates, in connection with everything else, an influence of Römer. Barnsdorf's zero lies somewhat higher than that of the later Fahrenheit thermometer. We have also other witnesses to the fact that Fahrenheit had used 7 1-2 at the freezing point, and that his zero originally stood somewhat higher than was later the case.

Professor Kirch, Berlin, describes, 1737, his thermometer[31] in connection with certain temperature observations which a friend in Pennsylvania had made with a thermometer of the same sort as his own; this thermometer had been given the friend by Kirch himself, 1727, and in the essay observations by Kirch in the year 1732 are mentioned. Consequently the essay must have been written between 1732 and 1737. Kirch's discussions are contained in the following:

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[28]Miscell. Berolienses, T. VI, printed 1740.
[29]l. c., p. 271.
[30]Cotte, Traite de Meteorologie, 1774, p. 129.
[31]Miscell. Berol., 5, p. 129, 1737.

1. My thermometer, which I have used several years, was made by the so skillful Fahrenheit more than twenty years ago. On it 24 degrees of heat are numbered; 0 denotes the greatest cold and 24 the highest heat. Two more degrees are introduced below zero, so that the degree of cold of the thermometer can be reckoned even when, in the case of extraordinary cold, its fluid contracts so as to withdraw below the limit zero.

2. This is a thermometer of small or medium size; its scale measures 5 Rhenish inches from 0 to the 24th degree. The single degrees are divided into four quadrants, so that from degree zero to the last division line there are 96 quadrants.

3. On the newer Fahrenheit thermometers the scale is no longer divided into 24 degrees and quadrants, but into 96 smaller degrees, corresponding to the 96 quadrants of the 24 degrees in which the older thermometers are divided.

4. The two sorts of graduation can easily be compared, since the quadrants of the larger degrees are quite equal to the smaller degrees.

5. Some years ago I noticed that my thermometer did not entirely agree with others of Fahrenheit, and so I ordered from the famous Mr. Fahrenheit a new and exact thermometer, so as to be able to compare with it my own and other thermometers. I found that this new thermometer agrees well with others of Fahrenheit, but differs noticeably from mine.

In paragraphs 6 and 7 Kirch treats the size of the discrepancies; at the highest and lowest temperatures they are not always the same; at the highest temperature they are 6 1-2 small degrees; at the lowest, 5, since the zero point of the old thermometers lies higher.

In 8, "The boundary between frost and thaw on my thermometer is at 7 1-2; on the new Fahrenheit thermometers at 36." (36 is correctly copied, though unexpected.—W. J. F.)

One more thermometer, perhaps the oldest of all, seems based on a graduation with fixed points and a scale like that of Barnsdorf, although the numbering is quite different. Grischow writes, 1740, that a large thermometer, made by Fahrenheit thirty years before for the Royal Society in Berlin, and consequently with every conceivable care, still agreed perfectly with a small thermometer that Fahrenheit had recently sent from Amsterdam to Berlin. These small thermometers were graduated by means of two or three fixed points and made exactly as we get them today. The first of these thermometers must therefore have been constructed according to quite definite principles[32]; for such an agreement cannot be accidental; a similar thermometer, used for observations 1709, surely one of the first made by Fahrenheit, was still in existence in Danzig in 1740.

This thermometer was apparently graduated like the Florentine; 90° at body heat, 0° at summer heat, 90° at the lowest degree of cold; at the freezing point of water stands 30°. From the

[32]Van Swinden, *Dissertation*, par. 34.

lowest degree of heat to the freezing point there are then 60 = 8×7 1-2°; from the lowest to the highest heat degree 180° = 8×22 1-2°; it is then apparent that this thermometer graduation is the same as Barnsdorf's, except that the large degrees are divided into eight smaller.

In 1714, Fahrenheit made two concordant thermometers for Freiherr Christian von Wolff, Chancellor of the University at Halle, who was very much pleased with them and has described them.[33] The scale had 26 degrees; the second degree of the scale was designated "greatest cold," and from there on to the upper end there were 24; at the eighth stood "cold." This reminds one exactly of the scale mentioned by Grischow as on the older thermometers of Fahrenheit, with the fixed points 0, 8, 24—later 0, 32, 96. Here Fahrenheit—perhaps like Römer, according to Horrebow's view,—had changed, and chosen 8 instead of 7 1-2. From this we get strong support for thinking that Fahrenheit's fixing of the freezing point at 32° is connected with Römer's directions for it.

In case Römer's scale is reproduced in that of Fahrenheit, one would expect to find the boiling point 4×60 = 240, and not 212. This can, however, be explained.[34] According to the above quoted descriptions of the oldest thermometers the zero of the newer thermometers lies lower than that of the older; if now these latter have the same zero as Römer's thermometer, their degrees must be shorter than those of the newer, since a shorter length contains the same number of degrees. In the newer thermometers the number of the boiling point was found by a division of the range zero (determined by a freezing mixture) to freezing point into 32 equal parts, and the continuation of this beyond the freezing point; since these degrees are longer than the older ones, there are fewer to the same range—hence 212 and not 240 at the fixed boiling point.

The thermometers of Fahrenheit, especially the quicksilver thermometers, are an extraordinarily great step in advance; by them the goal of equal indications for like thermal conditions had been closely approached. Yet till 1775 for the most part people kept on using thermometers of quite different construction, and with graduations which are only with difficulty convertible. In the writings on thermometers of those times one finds extensive tables for the conversion of long forgotten scales, as, e. g.,

[33] *Acta Eruditorum*, p. 381, 1714.
[34] See translator's note at end.

in Martine, Van Swinden and Lambert. Only three scales have endured to our time. The scale of Réaumur dates from the year 1730,[35] and is a backward step in comparison with Fahrenheit's; it was not originally founded on the application of two fixed points. In his graduation Réaumur used one fixed point and graduated the tube in fractions of the bulb volume. This graduation was done experimentally with the help of little pipettes and funnels; the tube could not then have been a capillary; the bulb must have been about two to three inches in diameter. So, first, this thermometer is very insensitive; second, the determination of the fixed point, the freezing point, is easily inaccurate, for much time must be spent in getting the bulb to the required temperature. Réaumur names 80° as the boiling point only in passing; he will rather make different thermometers agree by graduating their tubes by the method above described and filling them with the same fluid; he proposes to use wine spirit of a strength such that 1,000 volumes on heating from the freezing point to the boiling point of water expand to 1,080 volumes. But the method which he applies for testing this expansion can give no certain results. Later the thermometer of Réaumur was altered to its present generally known form.

Celsius[36] in his thermometer applies a rational sort of graduation; in doing so he takes account of the pressure variation of the boiling point of water.

Translator's Note.

A good and accurate account of the development of the thermometer is given by Cajori in his *History of Physics*, based largely on Gerland's book on the thermometer. As Römer's *Adversaria* was not published when these were written, his contributions are not stressed in them. But one must be on his guard against the statement that Huygens advised the employment of *two* fixed points. His letter of January 2, 1665, recommends the use of a tube whose volume is a known fraction of the bulb-volume, and one fixed point, *either* the ice point *or* the steam point. However, he seems to have preceded Halley and Amonton in observing the constancy of the water boiling point. The use of two fixed points, the melting points of ice and of butter, was advised by Dalencé, 1688.

There is discrepancy in the various books as to the date when Fahrenheit began to use mercury. But while some say that

[35] *Hist. et Memoires de l'Academie de Paris, annee* 1730, p. 452.
[36] Vetensk. Akad. Handl. Aar, 1742, p. 171.

he made thermometers before 1709, I think that the above account by K. Meyer renders it very improbable. She also makes clear, in agreement with others, that Fahrenheit used four scales, thus:

	Maker	Described by	Made	M.Pt.	Bl'd Ht.	B. Pt.	Zero
a	Römer	Römer, before 1710	1702-3	7.5		60	−14.3°C.
b	Römer	Horrebow, after 1739	before 1709	8	?	?	?
a	Fahrenheit	Grischow, 1740	1710?	−30	90		+9.2°C.*
a	Fahrenheit	Kirch, 1732-7	before 1712?	7.5			
a	Barnsdorf	Grischow, 1740	1712-3	7.5	22.5		−18.4°C.*
b	Fahrenheit	Fahrenheit, 1724	1724	32	96		−18.4°C.*
	Fahrenheit	Kirch, 1732-7	about 1737	36			
	Fahrenheit	Modern texts		32		212	−17.8°C.

Fahrenheit's and Barnsdorf's *a* seem based on Römer's *a*, but have a different starting point, −18.4° C., (*computed by taking the mean blood heat = 36.875° C.;) Fahrenheit's *b* is based on Römer's *b*, whose starting point is not known; though K. Meyer asserts, on what seems the inadequate evidence of Dr. Derham's account, that it was a freezing mixture temperature. However, Fahrenheit's *a* and *b* and Barnsdorf's *a* have the same starting point, −18.4° C.

Suspicions are voiced by some authors that Fahrenheit did not describe his actual method in his Philosophical Transactions account of 1724. And it does seem hard to believe that such good agreement as his instruments are reported to have shown could have been obtained with the shifting and uncertain zero point got "with a mixture of water, ice and sal ammoniac or sea salt," an experiment which worked "better in winter than in summer."

It may also be noted that Landolt and Björnstein, 1905, give the following values for the eutectic points of the mixtures used by Fahrenheit:

Ice 100 parts	Salt 28.9 parts	−21.2°C.
Ice 100 parts	Sal ammoniac 22.9 parts	−15.8°C.

Both of these are temperatures which differ considerably from the starting points of the Römer scale, −14.3°, and the Fahrenheit scales, −18.4° or −17.8°.

THE DUTY OF THE EMPLOYER IN THE RECONSTRUCTION OF THE CRIPPLED SOLDIER.

By Douglas C. McMurtrie,
Director Red Cross Institute for Crippled and Disabled Men, New York City.

We must count on the return from the front of thousands of crippled soldiers, and we must plan to give them on their return the best possible chance for the future.

Dependence cannot be placed on monetary compensation in the form of a pension, for in the past the pension system has proved a distinct failure in so far as constructive ends are involved. The pension has never been enough to support in decency the average disabled soldier, but it has been just large enough to act as an incentive to idleness and semi-dependence on relatives or friends.

The only compensation of real value for physical disability is rehabilitation for self-support. Make a man again capable of earning his own living, and the chief burden of his handicap drops away. Occupation is, further, the only means for making him happy and contented.

Soon after the outbreak of hostilities, the European countries began the establishment of vocational training schools for the rehabilitation of disabled soldiers. They had both the humanitarian aim of restoring crippled men to the greatest possible degree and the economic aim of sparing the community the burden of unproductivity on the part of thousands of its best citizens. The movement had its inception with Mayor Édouard Herriot of the city of Lyons, France, who found it difficult to reconcile the desperate need for labor in the factories and munition works, while men who had lost an arm or a leg but were otherwise strong and well, were idling their time in the public squares. He, therefore, induced the municipal council to open an industrial school for war cripples, which has proved the example and inspiration for hundreds of similar schools since founded throughout France, Italy, Germany, Great Britain, and Canada.

The disability of some crippled soldiers is no bar to returning to their former trades, but the injuries of many disqualify them from pursuing again their past occupations. The schools of training prepare these men for some work in which their physical handicap will not materially interfere with their production.

The education of the adult is made up largely of his working experience. The groundwork of training in his past occupation must under no circumstances be abandoned. The new trade must be related to the former one or be, perhaps, an extension or specialization of it. For example, a man who had done manual work in the building trades may by instruction in architectural drafting and the interpretation of plans be fitted for a foreman's job, in which the lack of an arm would not prove a serious handicap. A trainman who had lost a leg might wisely be prepared as a telegrapher, so that he could go back to railroad work, with the practice of which he is already familiar.

Whatever training is given must be thorough, for an adult cannot be sent out to employment on the same basis as a boy apprentice. He must be adequately prepared for the work he is to undertake.

The one-armed soldier is equipped with working appliances which have supplanted the old familiar artificial limb. The new appliances are designed with a practical aim only in view; they vary according to the trade in which the individual is to engage. For example, the appliance for a machinist would be quite different from that with which a wood turner would be provided. Some appliances have attached to the stump a chuck

in which various tools or hooks can interchangeably be held. The wearer uses these devices only while at work; for evenings and holidays he is provided with a "dress arm," which is made in imitation of the lost natural member.

An important factor in the success of re-educational work is an early start, so that the disabled man shall have no chance to go out unemployed into the community. In even a short period of exposure to the sentimental sympathy of family and friends, his "will to work" is so broken down that it becomes difficult again to restore him to a stand of independence and ambition. For this reason, therefore, the plan for his future is made at as early a date as his physical condition admits, and training is actually under way before the patient is out of the hospital.

In the readjustment of the crippled soldier to civilian life, his placement in employment is a matter of the greatest moment. In this field the employer has a very definite responsibility. But the employer's duty is not entirely obvious. It is, on the contrary, almost diametrically opposite to what one might superficially infer it to be. The duty is not to "take care of," from patriotic motives, a given number of disabled men, finding for them any odd jobs which are available, and putting the ex-soldiers into them without much regard to whether they can earn the wages paid or not.

Yet this method is all too common. A local committee of employers will deliberate about as follows: "Here are a dozen crippled soldiers, for whom we must find jobs. Jones, you have a large factory; you should be able to take care of six of them. Brown, can you not find places for four of them in your warehouse? And Smith, you ought to place at least a couple in your store."

Such a procedure cannot have other than pernicious results. In the first years of war the spirit of patriotism runs high, but experience has shown that men placed on this basis alone find themselves out of a job after the war has been over several years, or, in fact, after it has been in progress for a considerable period of time.

A second weakness in this method is that a man who is patronized by giving him a charity job comes to expect as a right such semi-gratuitous support. Such a situation breaks down, rather than builds up, character, and makes the man progressively a weaker rather than a stronger member of the community. We must not do our returned men such injury.

The third difficulty is that such a system does not take into account the man's future. Casual placement means employment either in a makeshift job as watchman or elevator operator—such as we should certainly not offer our disabled men except as a last resort—or in a job beyond the man, one in which, on the cold-blooded considerations of product and wages, he cannot hold his own. Jobs of the first type have for the worker a future of monotony and discouragement. Jobs of the second type are frequently disastrous, for in them a man, instead of becoming steadily more competent and building up confidence in himself, stands still as regards improvement and loses confidence every day. When he is dropped or goes to some other employment, the job will have had for him no permanent benefit.

Twelve men sent to twelve jobs may all be seriously misplaced, while the same twelve placed with thought and wisdom and differently assigned to the same twelve jobs may be ideally located. If normal workers require expert and careful placement, crippled candidates for employment require it even more.

The positive aspect of the employer's duty is to find for the disabled man a constructive job, which he can hold on the basis of competency alone. In such a job he can be self-respecting, be happy, and look for-

ward to a future. This is the definite patriotic duty. It is not so easy of execution as telling a superintendent to take care of four men, but there is infinitely more satisfaction to the employer in the results, and infinitely greater advantage to the employee. And it is entirely practical, even in dealing with seriously disabled men.

A cripple is only debarred by his disability from performing certain operations. In the operations which he can perform, the disabled man will be just as efficient as his non-handicapped colleague, or more so. In the multiplicity of modern industrial processes it is entirely possible to find jobs not requiring the operations from which any given type of cripples are debarred. For such jobs as they can fill the cripple should be given preference.

Thousands of cripples are now holding important jobs in the industrial world. But they are men of exceptional character and initiative and have, in general, made their way in spite of employers rather than because of them. Too many employers are ready to give the cripple alms, but not willing to expend the thought necessary to place him in a suitable job. This attitude has helped to make many cripples dependent. With our new responsibilities to the men disabled in fighting for us, the point of view must certainly be changed. What some cripples have done, other cripples can do—if only given an even chance.

The industrial cripple should be considered, as well as the military cripple, for in these days of national demand for the greatest possible output there should not be left idle any men who can be made into productive workers.

With thoughtful placement effort, many men can be employed directly on the basis of his past experience. With the disabled soldiers who profit by the training facilities the government will provide, the task should be even easier.

This, then, constitutes the charge of patriotic duty upon the employer: To study the jobs under his jurisdiction to determine what ones might be satisfactorily held by cripples; to give the cripples preference for these jobs; to consider thoughtfully the applications of disabled men for employment, bearing in mind the importance of utilizing, to as great an extent as possible, labor which would otherwise be unproductive; to do the returned soldier the honor of offering him real employment, rather than proffering him the ignominy of a charity job.

If the employer will do this, it will be a great factor in making the complete elimination of the dependent cripple a real and inspiring possibility.

THERMAL INSULATION.

The importance of thermal insulation as a factor in coal saving in steam plants under present conditions was emphasized at a recent meeting of the Providence (R. I.) Engineering Society in a paper by L. B. McMillan, consulting engineer, general power specialties department, H. W. Johns-Manville Company, New York. At present fuel costs, the author said, the losses of heat encountered in uninsulated pipe and fittings are very serious The loss of heat per square foot of bare pipe at 100 pounds pressure may easily represent the equivalent of more than one-third of a ton of coal per year at the pipe surface alone, or more than one-half ton at 150 pounds. The loss at the coal pile itself may be five or ten times as great. More attention should be given to insulating pipe flanges than in the past. A 10-inch bare flange at ordinary steam-plant pressures like the above may cost more than a ton of coal per year in fuel loss. From 80 to 90 per cent of these losses can be prevented.—[*Electrical World.*

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Glidden Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

Lists of questions are acknowledged from P. F. Hammond, University of Alberta, and W. P. Akin, Wichita Falls, Texas.

Science Tests.

Partial reports on tests as sent out by the Editor have been returned by the following:

O. W. Baird, Stadium High School, Tacoma, Wash.
H. E. Hammond, Central High School, Kalamazoo, Mich.
C. Arthur Smith, East High School, Salt Lake City, Utah.

J. L. Sloanaker, North Central High School, Spokane, Wash., and W. P. Akin, Wichita Falls High School, Wichita Falls, Texas, have asked to be enrolled among those interested in tests.

Tests on mechanics and on chemistry will soon be prepared and mailed to all who are on the list. Your assistance will be greatly appreciated.

QUESTIONS AND PROBLEMS FOR SOLUTION.

307. *Proposed by G. Ross Robertson, Riverside, Cal.*

Why is the rust, or tarnish, or corroded surface of common lead, grey or black? (The oxides of lead are yellow, red, or brown.)

308. Are the following questions *suitable* for school boys and girls, (granting that it is easily possible to teach them so that they may "pass" an examination)? If not, propose a few "test" questions of your own.

Physics.

College Entrance Examination Board, Friday, June 21, 1918 (Two Hours).

Answer ten questions as indicated below. No extra credit will be given for more than ten questions. Indicate clearly your reasoning in each problem and state the units in which each answer is expressed.

Group 1. (*Omit one question from this group.*)

1. (*a*) Explain the meaning of the terms acceleration, work, power, momentum, moment of a force.

(*b*) A balance has unequal arms, the left-hand arm having a length 99 per cent of that of the right-hand arm. A dealer has the habit of putting in the left-hand pan the articles which he sells. Who gains, the dealer or the customer? Why?

2. The water passing through the turbine water wheels at the Niagara power plant has fallen 136 feet. The average horse power of the turbines is 5,000 and their efficiency is 85 per cent. How many cubic feet of water does each turbine discharge per minute? (One cubic foot of water weighs 62.4 pounds.)

3. A painter's platform is 18 feet long and weighs 100 pounds. Its center of gravity is 8.5 feet from the right-hand end. The platform is hung in a horizontal position by two ropes, one attached one foot from one end, the other one foot from the other end. When a painter weighing 150 pounds stands at a point 7 feet from the left-hand end of the platform what weight does each rope support?

4. An aeroplane one mile above the earth is moving horizontally with a velocity of 60 miles per hour. A bomb is dropped from it in an attempt to hit a station. When the bomb is released, how far should the aeroplane be from the point ahead in its path which is directly over the station?

GROUP II. (*Omit one question from this group.*)

5. Describe an experiment, perferably one which you have personally performed, by which the wave length of a musical sound may be determined.

6. A man is standing two miles in front of a cliff. A gun, located between the man and the cliff, is fired. The man hears the report of the gun and, four seconds later, hears the echo of the report from the cliff. Taking the temperature of the air as 0°C., find the distance from the gun to the cliff.

GROUP III. (*Omit one question from this group.*)

7. Describe an experimental method of determining the coefficient of expansion of a gas under constant pressure.

8. A Centigrade mercury thermometer contains in its bulb and capillary tube up to the 0° mark .15 cubic centimeter of mercury. If the diameter of the capillary tube is .012 centimeter, what is the length of the tube from the 0° mark to the 100° mark? (The coefficient of apparent expansion of mercury in glass is .000156.)

9. How many kilograms of coal would be needed in a boiler having an efficiency of 65 per cent to convert 50 kilograms of water at 10° C. into steam at 100° C.? Assume that the heat value of the coal is 7,000 calories per gram.

GROUP IV. (*Omit one question from this group.*)

10. (*a*) Explain in terms of the wave theory of light the production of a spectrum by means of a prism.

(*b*) Describe the appearance of the solar spectrum.

11. (*a*) Describe an experimental method of determining the index of refraction of glass.

(*b*) The index of refraction of glass being 1.5, find the speed of light in it.

12. The works of a watch are held 1.5 inches from a jewler's eye-lens which has a focal length of 1.75 inches. How many times are the works magnified?

GROUP V. (*Omit one question from this group.*)

13. Using diagrams describe an electric telephone transmitter and an electric telephone receiver and explain the action of each.

14. A total current of 24 amperes flows through two branches of a divided circuit having resistances of 7 and 5 ohms, respectively. Find

(*a*) The strength of current which flows through each branch.

(*b*) The electromotive force required to maintain the current.

15. An electric motor having an efficiency of 85 per cent develops 3 horse power when connected to a 220-volt circuit. How much current flows through the motor? (One horse power = 746 watts.

AGRICULTURE.

University of Alberta Matriculation Examination, May, 1918. (*Two and One-Half Hours.*)

1. What is a seed? What is the importance, (1) to the crop grower, (2) to the consumer, of each of the following parts of a wheat seed? (*a*) The embryo; (*b*) the endosperm; (*c*) the epidermis of bran.

2. Compare the corn or wheat and pea or bean seed as follows: (*a*) before germination; (*b*) during the process of germination; (*c*) root and stem development following germination.

3. Discuss soil under the following headings: (*a*) origin; (*b*) color; (*c*) heavy and light soil; (*d*) open and compact soil; (*e*) rich and poor soil.

4. Define water holding capacity as applied to soil. Discuss each of the following in relation to its water holding capacity and give reasons for your answer: (*a*) sandy soil; (*b*) gumbo soil; (*c*) clay loam soil; (*d*) well cultivated soil (fallowed); (*e*) poorly cultivated soil (fall-plowed stubble); (*f*) soil low in humus or organic matter; (*g*) soil full of coarse strawy manure; (*h*) soil with a gravelly subsoil; (*i*) soil with a clay subsoil.

5. What effect does each of the following have upon the temperature

of the soil during the growing season? (*a*) Kind of soil; gumbo, sand and loam; (*b*) deep plowing of the summer fallow; (*c*) harrowing; (*d*) packing or rolling; (*e*) continued drought—a dry soil; (*f*) a dark colored soil; (*g*) a northern exposure.

6. (*a*) Describe two common plant diseases that injure farm or garden crops and give methods for the control of one.

(*b*) Give a description of: (1) ball mustard; (2) stink weed (French weed); (3) perennial sow thistle; and outline a method of controlling each.

7. What is the importance of bacteria to the agriculturist?

What do you understand by: (*a*) nitrogen-fixing bacteria; (*b*) denitrifying bacteria; (*c*) nitrifying bacteria?

What is the significance of introducing the appropriate bacteria into the soil when sowing alfalfa? What are the conditions necessary for the best bacterial reaction in the soil? How can the tiller of the soil control or influence this reaction?

EXCHANGE YOUR FIRST AND SECOND LIBERTY BONDS FOR THOSE BEARING 4 1-4 PER CENT INTEREST.

Bonds of the First and Second Liberty Loans may now and until November 9, 1918, be converted into 4 1-4 per cent bonds. Bonds delivered upon conversion will have the same maturity as the bonds surrendered. In all other respects they will be identical with the bonds of the Third Liberty Loan. This conversion may be effected through the subscriber's bank.

Holders of 4 per cent bonds of the First Liberty Loan Converted, presenting them for conversion on or before November 9, 1918, will receive in exchange, without an adjustment of interest, 4 1-4 per cent Gold Bonds of 1932-47, bearing interest at the increased rate from June 15, 1918.

Holders of 4 per cent bonds of the Second Liberty Loan, presenting them for conversion on or before November 9, 1918, will receive in exchange, without an adjustment of interest, 4 1-4 per cent Gold Bonds of 1927-42, bearing interest at the increased rate from May 15, 1918.

Holders of coupon bonds may receive at their option either coupon bonds or registered bonds; but registered bonds only will be delivered upon conversion of registered bonds, and such bonds will be registered only in the same name as the bonds surrendered for conversion. When registered bonds are presented for conversion, they should be assigned to "The Secretary of the Treasury for Conversion," on the form appearing on the backs of registered bonds. Such assignments, however, need not be witnessed.

All unmatured coupons must be attached to the bonds presented for conversion, and all matured coupons must be detached.

Holders of 3 1-2 per cent bonds of the First Liberty Loan, presenting them for conversion on or before November 9, 1918, will receive in exchange 4 1-4 per cent Gold Bonds of 1932-47, bearing interest at the increased rate from June 15, 1918, but such holders must pay the United States Government accrued interest at the rate of 3-4 per cent of 1 per cent per annum from June 15, 1918, to the date of conversion.

The conversion privilege on 4 per cent bonds of both the First and Second Liberty Loans expires on November 9, 1918, and they cannot be converted into subsequent issues of United States bonds which might come out at a higher rate. Therefore, holders of 4 per cent Liberty Loan Bonds should in every case present them for conversion. By converting these bonds they will not only receive 1-4 per cent of 1 per cent additional interest, but after the conversion period has expired (November 9, 1918) there will undoubtedly be several points difference in the market price of the 4 per cent and 4 1-4 per cent bonds.

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, completeness, *and* brevity *as essential.*

The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.*

Correction.

In connection with the proofs of No. 554 published in the May number, the Editor's attention has been called to the fact that the proof by I. E. Kline credited to Loomis was really first published in the American Mathematical Monthly (February, 1902) by G. I. Hopkins of Manchester, N. H. It also appears in Hopkins' book, *Inductive Geometry*, and Loomis acknowledges the authorship of the proof.

SOLUTION OF PROBLEMS.

Algebra.

561. *Proposed by the Editor.*

Factor

$x^2y+x^2z+xy^2+xz^2+yz^2+y^2z+2xyz.$

I. *Solution by Garland Martin, First Year Pupil, Warren (R. I.) High School.*

$$\begin{aligned}
&x^2y+x^2z+xy^2+xz^2+yz^2+y^2z+2xyz\\
&= (xy^2+2xyz+xz^2)+(x^2y+x^2z)+(y^2z+yz^2)\\
&= x(y+z)(y+z)+x^2(y+z)+yz(y+z)\\
&= (y+z)(xy+xz+x^2+yz)\\
&= (y+z)[(x^2+xy)+(xz+yz)]\\
&= (y+z)[x(x+y)+z(x+y)]\\
&= (y+z)(x+y)(x+z).
\end{aligned}$$

II. *Solution by Thomas Griffith, Junior, Riverside Polytechnic High School, Cal.*

$$\begin{aligned}
&x^2y+x^2z+xy^2+xz^2+yz^2+y^2z+2xyz\\
&= x(xz+xy+yz)+y(xz+xy+xz)+xz^2+yz^2\\
&= (x+y)(xz+xy+yz)+(x+y)z^2\\
&= (x+y)[x(y+z)+z(y+z)]\\
&= (x+y)(x+z)(y+z).
\end{aligned}$$

III. *Solution by Ruth A. David, Gibson City, Ill.*

By the factor theorem, the expression reduces to zero by the substitution $x = -y$. $\therefore\ x+y$ is a factor. Dividing the given expression by $x+y$, the other factor is found to be $xy+xz+z^2+yz$. This may readily

be factored by grouping so as to show the common binomial factor $y+z$, the other factor being $x+z$.

$\therefore\ x^2y+x^2z+xy^2+xz^2+yz^2+y^2z+2xyz = (x+y)(y+z)(x+z)$

A second solution was also received from Ruth A. David. *Solutions were also received from* Chas. Britton, Louise E. Church, K. C. Fitch, Nellie F. Henderson, Emma V. Hesse, S. J. Keusch, Murray J. Leventhal, Harold M. Lufkin, R. M. Mathews, M. B. Messinger, Ralph Moody, Edward J. O'Leary, Margaret O'Neill, Norris Olson, Howard R. Park, Everett Robinson, Philomathe, Walter S. Rodgers, Nelson L. Roray (2), H. H. Sampson, V. M. Spunar, Donald C. Steele, Sylvia Silverman, Henry S. Titus, Jacob A. Weiss, Josephine Wible *and* Harriet A. Wilcox.

562. *Proposed by Murray J. Leventhal, Stuyvesant High School, New York City.*

If n is a prime number, show that

$$\underline{|n-1}+1 \text{ is a multiple of } n.$$

Solution by Philomathe, Montreal, Can.

I. *Lemma.*—If n is a prime number, the product $2\cdot 3\cdot 4\cdots\cdots(n-3)(n-2)$ is a multiple of n, plus 1.

Let A be any factor of the product $2\cdot 3\cdot 4\cdots\cdots(n-3)(n-2)$, then there is another factor A′ of the same product, and only one, such that $A\times A' =$ mult. $n, +1$. For, if we divide $A\times 1$, $A\times 2$, $A\times 3$, $\cdots\cdots$, $A(n-1)$ by n we obtain for remainders, in any order, $1\cdot 2\cdot 3\cdot 4\cdots\cdots$, $n-2$, $n-1$. The multiple of A giving 1 as remainder is neither $A\times 1$, nor $A\times A$, nor $A(n-1)$, as could be easily made evident. Therefore, there exists a number A′, and only one, in the product $2\cdot 3\cdot 4\cdots\cdots(n-2)$ such that $A\times A' =$ mult. $n, +1$.

Now, the product $2\cdot 3\cdot 4\cdots\cdots(n-2)$ has an even number of factors, and it may be decomposed in groups of two factors, each group being a multiple of n, plus 1. Therefore, the product $2\cdot 3\cdot 4\cdots\cdots(n-2)$ is also a multiple of $n, +1$.

Theorem: $\underline{|n-1}+1$ is a multiple of n

Proof. From the lemma,

$$1\cdot 2\cdot 3\cdot 4\cdots\cdots(n-3)(n-2) = \text{mult. } n,\ +1$$

Multiply both numbers by $n-1$.

$$\underline{|n-1} = (\text{mult. } n, +1)(n-1)$$

or $\underline{|n-1} = \text{mult. } n,\ -1$

$\therefore\ \underline{|n-1}+1 = \text{mult. } n.$

Note. This is Wilson's theorem.

Geometry.

563. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Using the figure for the Theorem of Pythagoras as given on page 194 of Wentworth's *Plane Geometry* (Edition of 1899), prove

(1) BK, AL and FC are concurrent.

(2) Let X be the intersection of FC and AB, then GX, AD and BC are concurrent.

Prove by means of theorems that are usually given in Book I of plane geometry.

Solution by Philomathe, Montreal, Canada.

I. Let FG and KH meet at O. Then it can easily be proved that FC is $\perp$ to BO, BK is $\perp$ to CO, OA produced is $\perp$ to BC, $\therefore$ coincident with AL. Hence, FC, BK, AL are concurrent.

II. Next, produce AB in M, making BM = AC, and join MF, MG, MC; FC is $\perp$ to MG, MA is $\perp$ to GC, $\therefore$ GX produced is $\perp$ to MC. Now, let Y be the intersection of AD and MC; join XY, which is $\|$ to MF, or BD. In triangle XYC, DA is $\perp$ to XC, BC is $\perp$ to XY, GX (produced) is $\perp$ to YC; $\therefore$ GX, AD and BC are concurrent.

564. *Proposed by N. P. Pandya, Sojitra, B. B. and C. I. Ry., India.*

ABC is a triangle, right-angled at A. AP, AQ are squares on AC, AB, respectively. PB cuts AC at D. QC cuts AB at E. Show that DE is parallel to PQ.

I. *Solution by Emlyn Roberts, Pupil Dunmore (Penna.) High School.*

Let M be the vertex of the square AQ opposite B and R opposite C. Produce lines QM and RP and letter their intersection T. Triangle BAD is similar to triangle BRP. Line AD is parallel to line RP. Then BA : BR = AD : RP. Triangle QPC is similar to triangle QAE, line AE is parallel to line PC. Then QA : QP = AE : CP. Substituting CP's equal, AR, we get QA : QP = AE : AR. Triangle QBA is similar to triangle QTP, angle QTP equals angle QBA and angle TQA equals angle BAQ (alternate interior angles.) Then BA : QT = QA : QP; substituting equals, BA : BR = QA : QP.

From the three equations,

BA : BR = AD : RP,
QA : QP = AE : AR,
BA : BR = QA : QP,

AD : RP = AE : AR. Angle EAD equals the angle ARP (right angles.)

Therefore triangle EAD is similar to triangle ARP. Angle RAP equals angle AED, then ED is parallel to QP (if two lines are cut by a transversal and the corresponding angles are equal the lines are parallel).

II. *Solution by Emma V. Hesse, Petaluma High School, Petaluma, Calif.*

Produce DE to meet PC at X and BQ at Y. Then the rt. $\triangle$s XCD, DAE and EBY are similar.

Hence $DC/DA = XD/DE$, (1) and $AE/EB = DE/EY$. (2)

Multiply (1)$\times$(2): $DC/DA \cdot AE/EB = XD/DE \cdot DE/EY$.

Cancel DE, and $DC/DA \cdot AE/EB = XD/EY$.

Since $DC/EB = XD/EY$, AE/DA must $= 1$, that is, $AE = DA$; $\triangle ADE$ is isosceles, and so must $\triangle XDC$.

$\therefore \angle CXD = 45°$

But $\angle CPA = 45°$, $\therefore \angle CXD = \angle CPA$.

$\therefore$ DE (produced) is parallel PQ.

II. *Solution by Nellie F. Henderson, Martins Ferry, Ohio, and R. M. Mathews, Riverside (Cal.) Polytechnic High School and Junior College.*

If PB and QC intersect at O, then $\triangle$s QBO and DCO are similar and $QO/OC = BO/OD$.

Also $\triangle$s BEO and POC are similar and $EO/OC = BO/OP$.

Divide first equation by the second and $QO/EO = PO/DO$.

$\therefore DE \parallel QP$.

Solutions were also received from Ruth A. David, Paul W. Harnley, Murray J. Leventhal, Philomathe (2), Oscar J. Johnson, Nelson L. Roray, Jason A. Zurflich, *and one with no name attached.*

565. *Proposed by L. E. Lunn, Heron Lake, Minn.*

Prove that the lines joining the vertices of a tetrahedron to the centers of the opposite faces are concurrent at the centeroid of the tetrahedron and are quadrisected at this point. Use only elementary geometry.

Solution by R. M. Mathews, Riverside, California.

In tetrahedron ABCD let M be the center of edge CD, G_1 the centroid of face BCD and G_2 that of face ACD.

The three planes determined by one vertex and the median lines of the opposite face are coaxial for they contain said vertex and the centroid of that face. Each pair of these axes lies in one plane and they intersect. Thus AG_1 and BG_2 lie in plane ABM. When each of four non-coplanar lines cuts each of the others they are concurrent. So the axes meet at a point O.

Consider $\triangle ABM$. A parallel to AG_1 through G_2 cuts MG_1 in X such that $XG_1 = 2/3\ MG_1$. But MG_1 is 1/3 MB, whence $XG_1 = 2/9$ MB $= 2/8$ XB $= 1/4$ XB. $\therefore G_2O = 1/4\ G_2B$.

A solution was received from MURRAY J. LEVENTHAL *and one incorrect solution.*

Late Solutions Received.

554. Two solutions from A. E. Breece.
555. R. M. Mathews.
557. Gerald W. Willard, Heron Lake (Minn.) High School, N. P. Pandya.
560. N. P. Pandya.

PROBLEMS FOR SOLUTION.

Geometry.

576. *Proposed by G. Ross Robertson, Polytechnic High School and Junior College, Riverside, Cal.*

Construct an equilateral triangle with one vertex on each of three given unequally spaced parallel lines.

577. *Proposed by M. Costello, Brentwood, Cal.*

Construct a circle passing through two given points and bisecting a given circle.

578. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Equilateral triangles are constructed outward upon the sides of any triangle. Prove by elementary geometry only that the given triangle and the equilateral triangle whose vertices are the centroids of the equilateral triangles have the same median point.

579. *Proposed by N. P. Pandya, Amreli, Kathiawad, India.*

Two circles intersect at A and B. The sides DE, FD of a triangle touch both circles. EF intersects AB in C. If AB : AC = EK : EC, where K is the mid point of EF, find the possible positions of EF.

Trigonometry.

580. *Proposed by R. N. Mathews, Riverside, Cal.*

If P is the Brocard point of a triangle such that the angles PAB, PBC, PCA are equal, and p_1, p_2, p_3 its distances to a, b, c, respectively, then $p_1 : p_2 : p_3 = (a+c) : (a+b) : (b+c)$.

S. O. S.

The editor needs a fresh supply of good algebra problems.

P. S. Do not neglect the other kinds of problems.

P. P. S. Many problems proposed have been published before, either in books or in this journal. New practical problems are especially welcome.

PERSONALS.

Menton Rowand, recently principal of the high school at Bellefontaine, Ohio, has been appointed superintendent of schools at Zanesville, Ohio.

Professor Florian Cajori of Colorado College has been made professor of the history of mathematics at the University of California, Berkeley.

Associate Professor B. Clifford Hendricks, who has for the past ten years served the Peru, Neb., State Normal School in its department of physical science and nature study, has accepted a call to a position as assistant professor of general and physical chemistry in the University of Nebraska.

Mr. R. M. Mathews, for many years in connection with the high school at Riverside, Cal., has been made head of the department of mathematics in the Central High School, Duluth, Minn.

Professor Philip B. Woodworth, dean of electrical engineering of Lewis Institute, Chicago, has entered the Government service as a major in the aviation section of the Signal Corps.

Professor M. E. Graber, fellow in mathematical physics at the Univer-

sity of Chicago, has been elected to the professorship of mathematics in Heidelberg University, Tiffin, Ohio.

Mr. Louis M. Sears, for several years instructor in the Hyde Park, Chicago, High School, has accepted a position in the geography department at the Chicago Normal College.

Professor A. A. Michelson, head of the department of physics, University of Chicago, has been commissioned as lieutenant-commander in the Navy.

Professor G. A. Miller, of the University of Illinois, and associate editor of this Journal, has accepted the chairmanship of a committee which is to make a survey of the mathematical instruction given under the auspices of the Y. M. C. A. at the various naval stations.

W. V. Lovitt, Ph. D., Chicago, of the mathematical department of Purdue University, has been appointed associate professor of mathematics in Colorado College.

Dr. Elias J. Durand has been appointed professor of botany in the University of Minnesota. Dr. Durand was formerly an instructor at Cornell, but since 1910 has held a professorship in the University of Missouri.

Mr. Franklin T. Jones, who for many years has been dean of the University School, Cleveland, and since its beginning Editor of the Department of Science Questions in this Journal, has accepted a position with the Glidden Company, Cleveland, manufacturers of paints and varnishes, as their chemist. Mr. Jones will continue to act as Editor of Science Questions.

Dr. F. S. Nowlan, of Columbia University, has been appointed instructor in mathematics in Bowdoin College.

Professor Julius Stieglitz, chairman of the department of chemistry at the University of Chicago, has been appointed as special expert in the United States Public Health Service of the Treasury Department. This will not involve his work at the university. The Government assigns him two assistants, who will be in the employ of the Public Health Service and will carry out their work in Kent Chemical Laboratory under Professor Stieglitz's direction.

Assistant Professor Harvey B. Lemon, of the department of physics, University of Chicago, has been commissioned captain in the Ordnance Department of the Army and assigned to duty as head of the instrument division of the proof department of the Aberdeen Proving Ground, Aberdeen, Md.

Professor J. H. Ransom, after eighteen years in Purdue University, has accepted the professorship of chemistry and director of the chemical laboratories in Vanderbilt University, Nashville, Tenn.

Professor Henry Blumberg, of the University of Nebraska, has accepted a position in the mathematical department of the University of Illinois.

Professor E. V. Huntington, President of the Mathematical Association of America, has taken leave of absence from Harvard University and with the rank of major in the National Army is assigned to statistical study under the chief of staff with residence in Washington.

Professor A. D. Cole, professor of physics at Ohio State University, was in Washington during the summer, engaged in research work in the Bureau of Standards.

Dr. Richard C. Maclaurin, President of Massachusetts Institute of Technology, has accepted the appointment of director of college training, in charge of the students' Army Training Corps under the War Department's Committee on Education and Special Training, aiming to mobilize the higher institutions of learning.

Professor E. G. Lange of the Geography Department of the Whitewater Normal School, Wis., has resigned to enter Army Y. M. C. A. work.

Mr. J. A. Nyberg, for the past year instructor in mathematics in the Hyde Park, Chicago, High School, has received an appointment as instructor in mathematics in the Artillery Department of the United States Army.

Professor W. R. McConnell, of the geography department of the Platteville, Wis., Normal School, has been elected head of the department of geography in the Teachers Training College, Miami University, Ohio.

Dr. A. D. Brokaw, assistant professor of mineralogy and chemical geology at the University of Chicago, has been called to Washington to take charge of the oil production east of the Rocky Mountains.

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for July; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $5.00 per year, 60 cents a copy:* "A New Three-Salt Nutrient Solution for Plant Cultures," B. E. Livingston and W. E. Tottingham; "The Histology of the Phloem in Certain Woody Angiosperms," L. H. MacDaniels; "Cell Division by Furrowing in Magnolia," Clifford H. Farr.

American Mathematical Monthly, for June; *27 King Street, Oberlin, Ohio; $3.00 per year:* "On the I-Centers of a Triangle," N. Altshiller; "Note on Continuous Functions," K. P. Williams; "Note on Functions Which Approach a Limit at Every Point of an Interval," E. W. Chittenden; "The Nine-Point Circle Obtained by Methods of Projective Geometry," H. N. Wright; "Problems and Solutions."

Geographical Review, for August; *Broadway at 156th Street, New York City; $5.00 per year, 50 cents a copy:* "Alsace-Lorraine and Europe" (one insert map in color, five photos), Lucien Gallois; "Two Traverses Across Ungava Peninsula, Labrador" (one insert map, twelve photos), Robert J. Flaherty; "Traveling in China's Southland" (seven photos), Roy Chapman Andrews; "Portugal: The Country and The People" (six photos), William Thompson; "The Rumanians in Hungary" (three insert maps in color, one text map, two diagrams), B. C. Wallis.

Journal of Educational Psychology, for April; *Warwick and York, Baltimore; $3.00 per year, 50 cents a copy:* "An Experimental Study of Methods in Teaching High School Chemistry," William H. Wiley; "A Test in First-Year Chemistry," J. Carleton Bell; "The Range of Information Test in Biology. I. Physiology," N. M. Grier.

Journal of Geography, for May; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Finland," W. H. Twenhofel; "The Natural Resources of Australia," Stephen S. Visher; "The Project-Problem Method of Teaching Geography," Mendel E. Branom; "The Geography of Palestine," W. O. Blanchard; "The Magnesite Industry of Stevens County, Washington," C. E. Cooper; "Fur Seals and the Fur Seal Fisheries," Florence Whitbeck.

Popular Astronomy, for August-September; *Northfield, Minn.; $3.50 per year:* "Mars in 1911 and 1914" (Plate XV, Frontispiece), Latimer J. Wilson; "The Telescope and Mars" (Plates XV and XVI), Latimer J. Wilson; "Star Clusters," Russell Sullivan; "Nebular Evolution" (To be Continued), F. J. B. Cordeiro; "The Total Solar Eclipse of June 8, 1918" (Plate XVII), H. C. Wilson; "Total Solar Eclipse, June 8, 1918, Edwin B. Frost; "The Lowell Observatory Solar Eclipse Expedition," V. M. Slipher; "The Application of Schaeberle's Method in the Photography of the Corona at Matheson, Colorado, June 8," (Plates XVIII, XIX, and XX), Edison Pettit and Hannah B. Steele; "The William C. Sproul Eclipse Expedition," John A. Miller.

Physical Review, for August; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "On Electromagnetic Induction and Relative Motion. II," S. J. Barnett; "Electronic Frequency and Atomic Number," Paul D. Foote;

"Some Properties of Metals under the Influence of Alpha Rays," A. C. McGougan; "On the Specific Inductive Capacity of Metals," Fernando Sanford; "Polarization Measurements at Wire Cathodes in Separately Ionized Gases," C. A. Skinner; "Simplified Theory of the Cathode Fall in Gases with Application to Plates and Wires," C. A. Skinner; "The Magnetic Properties of Some Rare Earth Oxides as a Function of the Temperature," E. H. Williams.

Psychological Clinic, for June; *Woodland Avenue and 36th Street, Philadelphia; $1.50 per year, 20 cents a copy:* "Orthogenic Cases XII: Obadiah, a Child with a Numerical Obsession," Sarah W. Parker; "Effects of Smoking on Mental and Motor Efficiency," Oscar J. Johnson, University of Minnesota.

School World, for May; *Macmillan Company, London, England; 7s. 6d. per year:* "Man-Power and the Schools"; "The Cost of Science Teaching in Secondary Schools," Douglas Berridge; "Graphical Interpretation," R. Wyke Bayliss; "A Nature-Study Museum in a Rural School," Ernest R. Beale; "The Welsh University and the Secondary Schools," A. E. L. Hudson, B. A.; "The Position of Science in Schools"; "The Central-School System of London"; "Teachers and the Future of English Elementary Education."

CUT DOWN ON EXPENSE: LIVE THE SIMPLE LIFE.

Here are a few points on thrift given by the British Chancellor of the Exchequer which are worthy of emulation by Americans:

Lives must be lived more simply.

Personal, household, and business expenses must be reduced to the minimum.

Surplus weekly or monthly earnings, over necessary expenditures, must be invested straightway in war securities.

Current balances at the banks should be kept as small as possible and the money invested in war bonds.

Nobody's money can be neutral.

Money lent to the country fights for the country.

Money spent on luxuries and non-essentials is helping the enemy.—[*War Loan Reveille.*

MICA SCHIST FOR FURNACE LINING.

Mica schist is one of the commonest kinds of metamorphic rock and consists essentially of mica and quartz, with which may be associated certain other minerals, such as garnet and staurolite. Owing to its marked foliation, its softness, and its generally unattractive appearance, it has not been greatly used as structural stone or as paving or crushed stone. It was once quarried near Bolton, Conn., for use as flagstone, but it was too soft to withstand the wear upon it in places of much travel.

The mica, to which the softness of mica schist is due, however, successfully withstands a very high temperature, and as the stone can be readily cut into blocks of the desired shape, mica schist has therefore been used considerably as furnace lining. The mica schist quarried for this use is found in eastern Pennsylvania, at places conveniently near the metallurgical plants in which it is required. The quantity of mica schist produced for this purpose in 1917 was 39,975 short tons, an increase of 6,739 tons, or 20 per cent, over 1916, according to statistics compiled by G. F. Loughlin, of the United States Geographical Survey, Department of the Interior. The value of the output in 1917 was $85,986, an increase of $38,682, or nearly 82 per cent. The greater increase in value was due to a rise in price from $1.42 to $2.15 a ton, which largely represents the increased cost of production.

CLASSROOM SAYINGS.

A virtual image is the reflected image of an object. A real image is the image of the object itself made smaller or larger or changed in some similar way, or the same.

Velocity of light is in an almost instantaneous; in glass it takes longer, for there is more space to travel through, especially in prisms.

A galvanometer is an instrument used to determine whether a body contains electricity or not. (If it does).

The two-fluid voltaic cell does not have so much induction as the one-fluid voltaic cell.

Lightning is caused by the breaking of the electric sound in the clouds. It is a form of electricity. The only protective device which I know anything about is the lightning rod. I have heard that severe weather may make this type unsuccessful.

Draw a line through the point of contact of the two tangent circles exterminating in the circumferences. Equal arcs are sustained by equal chords.

"If one straight line meets another straight line, the sum of the adjacent angles will be equal."

"Side (*a*) is either equal, or it's not equal, or it's greater."

"A polygon is an angle of many sides."

"The dip of the earth is the angle at which the earth slants."

"An electrophorus is the instrument which is used in making electricity."

"Dielectric are electric waves that pass between the molecules as the wind passes through a forest."

"Dielectric is the faculty of not having electricity pass through readily."

"A right angle is an angle of 90° whose sides are equal and which has a common vertex."

CALL TO DUTY.

From the battle fields in France there comes an unspoken call that should find an answer in every American's heart. The recent great events in Europe, the successes of American arms on the fields of France should spur every American to greater effort.

Our people at home should not rest on the laurels of our soldiers in France. Every death on the field of honor in the line of duty and for our country's cause should be a call to us for every sacrifice and every exertion to aid the cause for which our soldiers are fighting, for which our soldiers have died.

Increase production, decrease consumption, save, and lend to the Government. Every cent lent to the United States is used to support, strengthen, and aid our soldiers in France.—[*War Loan Reveille.*

CENTRAL ASSOCIATION MEMBERS.

2125 Sherman Av., Evanston, Ill., Sept. 20, 1918.

My dear Fellow-Associationer:

Do you have a copyright on your educational knowledge? A few years ago one of the elementary teachers in a small town was talking with her principal about a wonderful grammar outline she had received in a summer course at the Normal School. She was willing that the principal should see it, but "Please don't show it to any of the other teachers for I paid my money for that and it is *mine*."

Happily the Central Association isn't built on that principle. We believe that every teacher should become 100 per cent efficient, and we believe that every member of the Association should help to attain this end.

We take for granted that you are glad to be a member of the Association, that you appreciate the privilege of associating with other progressive teachers at the annual meeting and of crossing intellectual swords with them, that you see in School Science and Mathematics a magazine unique and valuable, and that you appreciate the Proceedings as a concise summary of what transpired at the annual meeting. We also hope you approve of the attempt to make the Association of even wider influence through the Service Department.

This year we feel that a meeting of the Central Association is justified only as it takes account of war conditions and definitely strives to meet the changing conditions due to the World War. The program is based on this. Its central theme is "The Educational Demands of an Awakened Democracy." The committee on "Science and Mathematics in the High School of Tomorrow" expects to present individual reports to the various sections. Our president is emphasizing the importance of stressing this thought in his letters to the chairmen of the different sections.

Now, what are you going to do about it? Are you going to hoard your educational advantages, or are you ready to give the glad tidings to others that you have found a fountain of information and inspiration and want others to know about it? One of the men whom I most respect is the college professor who persuaded me to join certain educational associations.

We want *you* to get *at least* one new member for the Association this year. Bring out your former Proceedings; lend your copies of School Science and Mathematics. When the new programs appear about the first of November they will be first class advertising material. Use them. If a teacher says he cannot attend the meeting, remind him he is all the more in need of the printed reports of the meeting and of the monthly magazine.

Remember it is the *personal touch* that wins, and we want to double our membership through *you*. Lend a hand.

Sincerely yours,

CHARLES S. WINSLOW,

Chairman Membership Committee.

PRODUCTION OF FELDSPAR IN 1917.

The production of feldspar in the United States in 1917 amounted to 126,715 long tons of crude material, valued at $474,767. Eight states—North Carolina, Maine, Maryland, New York, Connecticut, Pennsylvania, California, and New Hampshire, named in order of magnitude of their production—contributed to this, the largest output ever recorded, it being 4 per cent, 42 per cent, and 7 per cent greater in quantity than the amounts for 1914, 1915, and 1916, respectively.

A BRIEF BIBLIOGRAPHY ON GAS WARFARE.

By B. J. Rivett,

Detroit Northwestern High School.

At present there is a great deal of interest in the subject of gas warfare, and it is especially important that the chemistry teacher be informed as to the composition of the gases and preventive measures used. Until recently there has been little literature available, but within the past three months several authoritative articles have been published. Probably the two most interesting discussions are those of Dean H. P. Talbot of the Massachusetts Institute of Technology and Major S. J. M. Auld of the British Military Mission. Any person interested in chemistry will be amply repaid by reading the books or any of the articles in the periodicals. The following is the list:

Atlantic Monthly, August, 1918—"Chemistry at the Front," by H. P. Talbot.

Scientific American Supplement, March 2, 1918—"Methods of Gas Warfare," by Major S. J. M. Auld.

World's Work, August, 1918—"German Liquid Fire," by Major S. J. M. Auld.

Saturday Evening Post, May 25, June 1, June 8, and July 6, 1918—Articles by Major S. J. M. Auld.

Scribner's Magazine, June, 1918—"Gas Attack," by Emmanuel Bourcier.

Journal of Laboratory and Chemical Medicine, October, 1917.

The book, *Manual of Gas Attack and Defense*, by Major William Kirby, published by Edwin N. Appleton, Broadway, New York City.

The book, *Trench Fighting*, by Captain F. H. Elliott, published by Houghton, Mifflin & Company, Boston.

WHAT WAR DOLLARS DO!

The attention of owners of Liberty Bonds is called to the following· They are financing the work:

On one day in June approximately 27,000,000 cartridges of various descriptions were produced in the United States manufacturing plants for the United States Government.

The daily average production of United States Army rifles was broken in the week ending June 29, an average of 10,142 rifles a day of a modified Enfield and Springfield type being maintained. In addition spare parts equivalent to several thousand rifles and several thousand Russian rifles were manufactured.

The Ordnance Department has produced 2,014,815,584 cartridges, 1,886,769 rifles, and 82,540 machine guns since the United States entered the war. The daily output of cartridges is now 15,000,000.—[*War Loan Reveille.*

BOOKS RECEIVED.

A Calendar of Leading Experiments, by William S. Franklin and Barry MacNutt. Pages viii+210. 15×22 cm. Cloth, 1918. $2.50. Franklin, MacNutt & Charles, Publishers, South Bethlehem, Pa.

Palladin's Plant Physiology. Translation. Edited by B. E. Livingston. Pages xxv+320. 15.5×23 cm. Cloth. 1918. P. Blakiston's Son & Company, Philadelphia.

The Anatomy of Woody Plants, Y. E. C. Jeffrey. Pages x+478. 15.5×23 cm. Cloth. 1917. University of Chicago Press.

Plant Genetics, by J. M. Coulter, University of Chicago, and M. C. Coulter. Pages ix+214. 13.5×19.5 cm. Cloth. 1918. University of Chicago Press.

Junior High School Mathematics, Books II and III, by George Wentworth, David E. Smith, and Joseph C. Brown.

Book II, pages vi+250. 13.5×19 cm. Cloth. 1918. 76 cents. Book III, pages vi+282. 13.5×19 cm. Cloth. 1918. 96 cents. Ginn & Company, Boston.

Elementary General Science, by Daniel R. Hodgdon, Normal School, Newark. Pages xxii+553. 15×20.5 cm. Cloth. 1918. $1.50. Hinds, Hayden & Eldredge, New York City.

Elements of General Science, Revised Edition, by Otis W. Caldwell, Teachers College, Columbia University, and William L. Eikenberry, University of Kansas. Pages xii+404. 13.5×20 cm. Cloth. 1918. Ginn & Company, Chicago.

The Main Currents of Zoology, by William A. Lacy, Northwestern University. Pages vii+216. 13×19 cm. Cloth. 1918. $1.35. Henry Holt & Company, New York City.

Industrial Arithmetic for Girls, by Nelson L. Roray, Dickinson High School, Jersey City. Pages viii+196. 12.5×19 cm. Cloth. 1917. 75 cents net. P. Blakiston's Son & Company, Philadelphia.

Economy in Food, by Mabel T. Wellman, Indiana University. 36 pages, 13×19 cm. Cloth. 1918. 30 cents net. Little, Brown & Company, Boston.

Second Course in Algebra, by Herbert E. Hawkes, Columbia University, William A. Loby, Kansas City Polytechnic Institute, and Frank C. Touton, Central High School, St. Joseph, Mo. Pages vii+277. 13×19 cm. Cloth. 1918. $1.00. Ginn & Company, Boston.

General Science Manual by Leland R. Thompson. High School, East Chicago, Indiana. 101 experiments. 21x27 cm. Cloth covers. Atkinson, Mentzer and Co., Chicago.

A NEW SERVICE DEPARTMENT.

The Central Association of Science and Mathematics Teachers is inaugurating a new department—the Service Department. It has always been the aim of the Association to render service to its members through its meetings, its magazine, and its printed *Proceedings*, but it desires to be of even greater service in the realm of science and mathematics to the individual teacher.

Purpose.

The purpose underlying the inauguration of this new department is to give the individual teacher, wherever he may be, assistance in solving his problems. D. A. Lehman of Goshen College, Goshen, Ind., Corresponding Secretary of the Association, is the secretary of this Service Department. All inquiries received by him will be referred for answer to various teachers prominent in their lines of work.

Suggested Lines of Inquiry.

Supplies.—Latest or most efficient apparatus for demonstrating certain problems; special reference books; lists of publications by United States Government; names of reliable supply houses.

Professional Development.—Information and advice concerning summer courses, requirements for admission into various school systems (procedure necessary, type of examination, etc.), efficiency measurement cards, vocational guidance.

Problems.—Information upon matters involving reference work in Chicago libraries. Solution of practical classroom problems and teachers' "troubles."

Motto.—"The Association Lives to Serve."

Address, D. A. Lehman, Goshen College, Goshen, Ind.

BOOK REVIEWS.

A Calendar of Leading Experiments, by William S. Franklin and Barry MacNutt. Pages viii+210. 15×22 cm. Cloth. 1918. $2.50. Franklin, MacNutt & Charles, South Bethlehem, Pa.

A book equally as interesting to the physics layman as to the physics teacher. It is written in the author's characteristic style. They see the fun and humor of teaching as well as the serious phase. It will surely arrest and hold the student's attention and thus secure the results to be sought. The book has fundamentally to do with classroom experiments, those being selected which have a suggestive and investigational nature rather than those which give nothing but information. It is refreshing to get hold of a book which actually does break away from formalism and invites the student into the confidence of the instructor.

C. H. S.

Plane Trigonometry, with tables, by Eugene H. Barker, Head of Department of Mathematics, Polytechnic High School, Los Angeles, Cal. Pages 172. 16x24 cm. 1918. $1.00. P. Blakiston's Son & Co., Philadelphia.

In accordance with the author's belief he has emphasized the following: a thorough familiarity with trigonometric functionality, acquaintance with the inter-dependence of the functions, a knowledge of the methods of trigonometric analysis, power of initiative in the development of formulas, and a certain definite resolute skill in their application to the solution of practical problems. These things are presented and discussed in a direct and understandable fashion, while the pure mathematics side of the subject is largely omitted. The student is shown how to put his computations in compact form, and to check his results. The figures are well drawn and the pages present an inviting appearance.

H. E. C.

Logarithms and Anti-Logarithms, by C. H. Forsyth, Ph. D., Instructor in Mathematics in the University of Michigan. Pages 45. 15.5x23.5 cm. 1915. 75 cents. George Wahr, Ann Arbor, Mich.

The tables include five-place logarithms of numbers, five-place numbers to logarithms, the first seven powers of numbers to 100, and squares of numbers to 1000.

H. E. C.

Advanced Algebra, by W. C. Brenke, Professor of Mathematics in the University of Nebraska. Pages 196. 14x21 cm. $1.25. 1917. The Century Co., New York.

This text contains for the most part the material of the chapters on algebra in the author's *Advanced Algebra and Trigonometry.* Some matter has been added, some has been omitted, while the form of presentation has been altered in a number of places, exercises changed, and all the figures have been redrawn. The usual topics of the course in college algebra are covered with a well-arranged review of elementary algebra. Numerous simple applications are given in the exercises and problems. Graphic methods and logarithms are introduced early and used in the solution of problems throughout the book. These things, in addition to well-selected material and clear presentation of theory, should make it a very satisfactory textbook.

H. E. C.

Plane and Spherical Trigonometry, with tables, by W. C. Brenke, Professor of Mathematics in the University of Nebraska. Pages vi+121+39. 14×21 cm. 1917. $1.25. The Century Co., New York.

This book contains in revised form and with some additions the material of the author's textbook, *Advanced Algebra and Trigonometry*. The illustrations are instructive, and a large amount of graphic work is given in the exercises throughout the book. While all the topics and methods of trigonometry as a mere tool for the practical man are included, there is also some excellent work in vectors, harmonic analysis, trigonometric equations, complex numbers, and hyperbolic functions that the technical student really needs. The plan of giving answers to odd-numbered exercises only is good. A cardboard protractor, in degrees and radians, is provided in a pocket inside the book cover. In addition to tables of logarithms are natural functions, conversion tables, degrees to radians and, conversely, mathematical constants, log x to base e, e^x and e^{-x}, and squares, cubes, square and cube roots.

H. E. C.

Junior High School Mathematics, Second Course, by William L. Vosburg, Head of Department of Mathematics, The Boston Normal School, and Frederick W. Gentleman, Junior Master, Department of Mathematics, The Mechanic Arts High School, Boston. Pages x+212. 13×19 cm. 1918. 90 cents. The Macmillan Company, New York.

This *Second Course* aims to bring the pupil who leaves school at the end of his eighth school year in contact with adult activities that require some knowledge of mathematics, and to aid the pupil who continues in school in deciding whether or not he is capable of continuing his work in mathematics with profit. It includes arithmetic of the home, farm, and city, mensuration, and linear equations. Those who are interested in the newer phases of junior high school mathematics will find it worth while to examine the two books in this series.

H. E. C.

The Course in Science, Vol. V, Francis W. Parker School Year Book. 168 pages. 64 illustrations. Francis W. Parker School, Chicago.

The *Year Book* presents the science work as taught in this school, throughout both the elementary and high school grades. It represents a distinct step towards a new and improved school curriculum, and is the result of a number of years of independent, experimental, and developmental work on the part of many members of the faculty.

It has not been written by a few in authority, with the expectation that other teachers will slavishly follow it, but as an attempt to improve the choice of materials, to suggest better methods of presentation, and to unify the science instruction of the school.

Following a presentation of the general principles underlying the organization of the course, the detailed outlines are given grade by grade and course by course, showing how all the work in science may be based upon the interests, activities, and problems of the pupil. Not only is the course given in outline, but the outcome is indicated by many examples of the pupil's work, as shown by their own papers, or as given in morning exercises. The experimental work is fully presented, together with many references for class reading or as aids to the teacher.

The book is well illustrated, and should be of interest to all teachers in the elementary school, to high school teachers of science, and to principals and superintendents interested in the making of a vital school curriculum based upon the interests and activities of the children.

R. W. O.

Infinitesimal Calculus, Section II, by F. S. Carey, Professor in the University of Liverpool. Pages x+352. 14.5×22.5 cm. 1918. $3.00. Longman, Green and Co., New York.

The topics covered in this section include exponential and hyperbolic functions, motion of a particle along an axis, definite integrals, arc formulas, partial differentiation, double integration, expansion in power series, curve tracing, envelopes, evolutes, roulettes, differential equations, graphics, and nomography. While much space is given to the development and discussion of principles and formulas there are many applications in geometry, physics, and mechanics. Students in calculus will find these two sections of *Infinitesimal Calculus* of value as books of reference.

H. E. C.

Predetermination of Prices, by Frederic A. Parkhurst, M. E., Organizing Engineer. Pages viii+96. 15×23 cm. 1916. $1.25. John Wiley & Sons, Inc., New York.

In this book the author presents an argument on the possibilities of predetermining true costs, basing it on his own experience and the results of his methods during several years. The first chapters emphasize the fact that true costs cannot be obtained at any time unless all methods incidental to processing are under absolute control. The last chapter discusses the possible ideal, which can be attained through the science of management. The methods used are made plain by a large number of diagrams and illustrations of order forms, work order forms, time cards, and cost sheets.

H. E. C.

Scientific Method in the Reconstruction of Ninth-Grade Mathematics, by Harold O. Rugg, Associate Professor of Education in the School of Education, University of Chicago, and John R. Clark, Chairman, Department of Mathematics, Parker High School, Chicago. Pages vi+190. 17×24 cm. Paper. 1918. $1.00. The University of Chicago Press.

During the ten or fifteen years that secondary mathematics has been under fire of friend and foe, various methods of investigation have been used and various correctives have been proposed. On the one hand we have the manner of procedure of a few authoritative specialists who arrive at conclusions through reflective assurance; and of superintendents and supervisors of schools who assign instruction in mathematics to teachers on the basis of convenience and saving of expense with little regard to their qualifications and abilities. In either case, possible questionnaires are sent out, hurried investigations are made, and then comes the grand pronunciamento, the teaching of mathematics in our high schools is a failure, let it be abolished.

In marked contrast to this procedure we have in this monograph a report of a long-continued and well-planned study of the fundamental causes of the inefficiency of mathematics teaching, and a well-founded program for reconstructing ninth-grade mathematics. Above all it is an earnest call to teachers and supervisors of mathematical instruction throughout the country to coöperate in making such a program effective. What has been done by the authors and what can be done by teachers to aid in this work is clearly set forth in the following topics: an inventory of the material of the present course in algebra, how algebra became the ninth-grade course, the design and construction of standardized tests and what they reveal, development of abilities through drill, training in "logical thinking," curriculum-making in secondary mathematics, experimental teaching, and a program for the reconstruction of ninth-grade mathematics.

H. E. C.